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CONTENTS:

	PAGE
The Jacques Carbon Generator	351
Röntgen Ray Hypothesis	353
Construction of a Tesla-Thomson High Frequency Coil (*illustrated*)	354
The Roasting of Iron Ores with a View to their Magnetic Concentration	355
Faults in Dynamos (*illustrated*)	356
Technical Education	357
A National Submarine Telegraph Memorial	358
Correspondence:—On Celluloid and Accumulators	360
A Problem in Electro-dynamics	360
The Telegraphist and the Tiger	360
Business Notices, &c....	360
Electric Lighting Notes	361
Electric Traction and Motive Power Notes	363
Telegraph and Telephone Notes	363
Contracts Open and Closed	364
Electricity Down a Coal Mine (*illustrated*)	365
Electrical Factories and Their Machinery.—III. (*illustrated*) ...	368
The Lighting of Great Eastern Railway Company's Station (*illustrated*)	369
The Oerlikon Company at the Geneva Exhibition (*illustrated*)	372
Technical Education in England and Germany	373
Notes	373
City Notes	377
Traffic Receipts	377
Share List of Electrical Companies	378
Small Electric Lighting Plants for Country Houses	379
A Completed Chapter in the History of the Atomic Theory ...	380
Applied Electro-Chemistry	382
Emancipation from Scientific Materialism	384
New Patents	386
Abstracts of Published Specifications	386

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THE JACQUES CARBON GENERATOR.

WE published some time ago (ELECTRICAL REVIEW, Vol. xxxviii., p. 826) an article on a battery invented by Dr. Jacques, of Boston, U.S.A., in which he alleged that electric energy was obtained by the direct combustion of carbon dipped in a bath of fused caustic soda. We mentioned at that time that Mr. C. J. Reed, an investigator who has specially devoted himself to this field of study, considered that there was no such thing as combustion of carbon, or anything else, inside the cell, but that the so-called galvanic battery consuming carbon was merely a thermo-electric generator, deriving its electromotive force from the difference of temperature of the junctions of the fused soda with the carbon and iron.

Mr. Reed has since that time made a series of experiments, which leave no doubt that his theory of the Jacques generator was the right one. This might have been inferred from the comparatively ancient experiments of Andrews, Hankel, and others which we quoted (Jablochkoff made a battery to all intents and purposes identical with this (see ELECTRICAL REVIEW, page 292, Dec. 1st, 1877); but as there still appears to be a belief abroad, even among scientific men, that Dr. Jacques has at last caught this *ignis fatuus* of the electrician, we think it advisable to give some account of Mr. Reed's experiments, so that this startling invention may, like so many of its predecessors, be consigned, once for all, to the limbo of stillborn projects.

Mr. Reed made three experiments to determine whether or not the action of this generator was thermo-electric. A quantity of caustic soda was placed in a sheet iron cup, with a long iron handle, connected by a wire to one terminal of a voltmeter. The other terminal of the voltmeter was connected by a flexible wire to a conducting rod, which could thus be dipped when necessary into the cup. The cup was then heated by a Bunsen burner, and readings were taken by dipping the rod into the caustic soda at intervals of about 1 minute from the time the alkali fused till the highest attainable temperature was reached.

Rods of carbon, nickel, copper, iron, German silver, lead, and cadmium, were used. They all gave E.M.F. curves of the same general shape, as the temperature increased. The E.M.Fs. were at first positive, but a change from positive to negative took place a little below red heat—a change which is in accordance with the thermo-electric behaviour of substances generally, but cannot be reconciled with any rational theory of galvanic or chemical action. A careful examination of the carbon rod, before and after the experiment, and also after prolonged use in other experiments, showed not the slightest indication of any change such as combustion would produce. The maximum E.M.F. obtained from some of the metals was notably greater than that obtained from carbon.

In order to make a comparison of different materials under as nearly as possible the same conditions, another experiment was made. Three rods, one of carbon, one of copper, and

one of iron, were insulated by sheet asbestos and held close together in a vertical position by a suitable clamp, and the lower ends of the rods were dipped in the fused alkali. By means of a suitable switch, these three rods could be rapidly connected in succession to the voltmeter. The temperature of the alkali was gradually raised as in the former experiment. The experiment showed that the highest E.M.F. was produced with the iron rod, which at a certain temperature below red heat gave 1·15 volts. This is a remarkably high voltage for any thermo-electric couple, especially when we consider that it must be due to the comparatively small difference of temperature between the junction of the fused alkali with the pot and its junction with the iron rod. The maximum E.M.F. obtained with the carbon rod was 0·65 volt.

The blast of air used by Dr. Jacques merely served to increase difference of temperature between the two junctions, for Mr. Reed found that a jet of coal gas had exactly the same effect as the air; so that the chemical action of the oxygen of the air on the carbon could not possibly have had anything to do with it.

In Mr. Reed's third experiment, a long piece of iron gas pipe, bent into the form of a V, was substituted for the rods. A blast of cold air was continually blown through the pipe. The highest E.M.F. attained in this case was ·94 volt. In this experiment, and in the previous one, the iron rod or pipe remained positive to the cup, while in the first experiment the iron rod became negative at a high temperature.

These experiments of Mr. Reed appear to leave no opening for the view that the electric energy of the Jacques generator is derived from the chemical combustion of the carbon in the cell. The energy of the Jacques generator is therefore entirely derived from the combustion of the fuel consumed outside the generator, to maintain the alkali in the fused condition, and supply the heat lost by radiation and absorbed at the junctions by the Peltier effect; and Dr. Jacques thought fit to neglect the cost of this fuel in the calculation of the 82 per cent. efficiency of his generator. Such neglect is characteristic of the enthusiastic or ignorant inventor who can see nothing that tells against his pet idea, but does not say much for the scientific training and scientific spirit in America.

But not American doctors alone appear to have been taken in by this plausible idea. On this side we have recently had a protest in a letter to the *Liverpool Post* from Mr. M. Whitley Williams, late Professor of Chemistry, Queenwood College, Hants, against giving the credit to an American of so great a discovery as the direct conversion of carbon into electrical energy. He alleges that in 1885 he made the Jacques experiment, and obtained a powerful current by dipping ignited carbon into a mass of oxidised alkaline salt. Mr. Reed's experiments will now convince Mr. Whitley Williams that he would have got an equally good, if not a better, result by using iron instead of carbon, and that no such thing as a useful combustion of carbon takes place. Mr. Williams winds up with an appeal to Britain to value her own inventive sons, and to distinguish and foster them. The occasion for this appeal is, in the present case, unfortunate, and he may for once be willing to let America have all the credit.

It is no objection to Dr. Jacques' invention that it is a thermo-electric generator, except that hitherto thermo-electric generators have shown a remarkably low efficiency. Instead of 82 per cent. which the calculations give on the assumption that the generator is a galvanic battery, as a thermo-electric generator the efficiency is more probably less than 1 per cent. However, the elements of the thermo-couple are rather unusual, and it is just possible that the efficiency may be somewhat higher. It is to be hoped that, at least as a matter of scientific interest, some accurate tests of the generator will be made, in which the fuel consumed in heating the pot is not neglected.

Electricity in Horticulture.

During the last six years experiments have been conducted at Cornell University with a view to determining the influence of electricity in horticulture. The progress of this investigation has been noted in its various stages, and a report recently made by Prof. L. H. Bailey is of special interest. In the early investigations it was determined that the electric light profoundly affects many plants, some injuriously, and a few beneficially. Very minute details are given in the report concerning the candle-powers of the light used, the effects of naked and protected lamps, the areas of the greenhouses illuminated, the crops grown, &c. One point is recorded which is interesting, on account of its practical bearing. Mr. W. W. Rawson, of Arlington, near Boston, now uses the electric light in the commercial forcing of lettuce. The house is 33 by 370 feet, covering nearly one-third of an acre. Along the north side of this house are three 2,000-candle-power lamps, which are run all night. Mr. Rawson calculates that he receives a gain of five days on a crop of lettuce by the use of these lamps, and as he grows three crops during the winter, the total gain is over two weeks of time. The gain from one crop is estimated to pay the cost of running the lights all the winter. The effect of the light is said to be marked even at a distance of 100 feet. Prof. Bailey enumerates many other instances showing the effect of the electric light upon plants and flowers. He has compiled statistics on this subject, and from them draws the conclusions that the electric light does not determine the periodicity of growth; that increase under the light occurs only during the first days; that growth takes place in daylight as well as in darkness. The experiments are thus summarised:—The influence of the electric arc light upon greenhouse plants is greatly modified by the use of a clear glass globe, or the interposition of a glass roof. Plants which are much injured by a naked light may be benefited by a protected light. The light can be suspended above the house with good effect. As a rule, plants are earlier under the electric light than when grown in ordinary conditions. Lettuce is greatly benefited by the electric light. An average of five hours of light per night hastened maturity from a week to 10 days, at the distance of from 10 to 12 feet. Even at 40 feet, in only diffused light, the effect was marked. The light appeared to injure young newly transplanted plants. Radishes were also benefited by the light, but not to a great extent. When the light was hung in the house, however, whether naked or protected by a globe, radishes were injured. Beet and spinach appeared to be slightly benefited by the light. Cauliflowers under the light tended to grow taller than in ordinary conditions, and to make fewer and smaller heads. Violets and daisies bloomed earlier in the light house. This corroborates results obtained with other flowers in the earlier experiment. The electric light does not appear to determine or modify the hours of growth of lettuce and some other plants which have been studied in this particular. Plants which are benefited simply grow more rapidly during the customary periods. Concluding, Professor Bailey says:—"I am convinced that the electric light can be used to advantage in the forcing of some plants." Now this conclusion is arrived at after a series of experiments extending over six years, and is therefore worthy of careful attention. It is not the view of an enthusiast, but of an independent scientific man who has no object but to ascertain the truth. Consequently, enterprising horticulturists, who desire to be first at Covent Garden with their early salads, &c.—a branch of industry which we understand to be exceedingly profitable—need not hesitate to instal the electric light in a few of their forcing houses. Judging by the American results, they should find that such installations will well repay them.

RÖNTGEN RAY HYPOTHESES.

Though the hypotheses concerning the nature of the Röntgen rays are not so numerous as they were some time ago, there is as yet by no means general agreement among physicists on this question. In this country and in France, the transverse wave theory has lately come into great favour. This theory is advocated by such great authorities as Sir G. Stokes and Lord Kelvin, and their lead has been promptly followed by a number of the smaller fry; Sir G. Stokes, however, has, unfortunately for the smaller fry, been quite recently showing signs of recantation.

The arguments in favour of the transverse vibration, or ultra-ultra-violet theory are chiefly of a negative character. Becquerel, Henry, and others have made experiments which appear to show that the phosphorescent light emitted by certain salts, especially salts of zinc, calcium, and uranium, is capable like the X rays of passing through opaque bodies and affecting the photographic plate. "The Becquerel rays," to quote Prof. Lodge, "are capable of some amount of polarisation, and hence are certainly transverse disturbances like light; they can also be reflected and refracted to a small extent, whereas the X rays can be hardly at all reflected and not at all appreciably refracted. Neither kind can be deflected by a magnet, not even in a vacuum, according to the experiments of M. Lagrange; and an assertion that the X rays could be magnetically deflected after passage through an electrified plate has not been substantiated by careful experiments, made by the writer among others. Taking all these things together and looking at them in the light of a notable dispersion theory of Von Helmholtz, it has become almost certain that they are simply an extraordinary extension of the spectrum, far beyond the ordinary ultra-violet, and that the Becquerel rays are a less extreme extension in the same direction."

The dispersion theory of Von Helmholtz is based on the electro-magnetic theory of light, and shows, by a mathematical investigation, what would be the refraction experienced by light of different frequencies passing through an ideally simple substance, *i.e.*, a substance whose spectrum consists of only one line. According to this theory, transverse waves in the ether are refracted more and more as the wave length becomes shorter, up to a certain maximum; this, of course, corresponding to refraction in the ordinary spectrum. As the waves become shorter still the refractive index drops nearly to zero, that is, the rays are bent the wrong way; Kundt showed that certain rays which pass through gold are bent back in this way. For this kind of waves, the opacity of matter should be very high. If, however, the length of the waves be still further reduced, then the opacity decreases and the refractive index rises slowly to about unity, a value which it maintains however much the length of the waves is reduced.

The theory of Von Helmholtz, therefore, would show that the fact that the Röntgen rays cannot be refracted is no objection to their being transverse vibrations in the ether, like ordinary light. It is, however, no positive proof that the X rays are transverse vibrations; and if, like most mathematical theories, it contains many unverified assumptions, it may yet, with fuller knowledge, have to be modified, and the whole fabric built upon it will fall to the ground.

Even the evidence in favour of the photographic action of the Becquerel rays through opaque bodies is somewhat conflicting. So high an authority on photographic matters as Carey Lea, has not been able to obtain the Becquerel effect. He says,* "A dilute solution of uranin was exposed to sunlight, using a large surface of solution so as to get the best effect. A short distance over the surface was placed a sensitive film protected by aluminium foil $\frac{1}{10}$th of a millimetre in thickness and with a lead star interposed. Two hours exposure gave no result. The experiment was repeated with acid solution of quinine, with which five hours exposure gave no result." Another experiment, described by Carey Lea, may explain how it is that X ray effects have been obtained from so many different kinds of radiation. "Three thicknesses of Bristol board were pasted together, a circle was cut out, to one side of which barium platino cyanide was applied. The circle was then placed in a pasteboard tube. When the sun was looked at through this tube, the barium salt exhibited fluorescence. But the intervention between the card and the sun of very thin aluminium foil sufficed to cut off the fluorescence."

There appears, therefor, to be no direct positive evidence in favour of the ultra-ultra violet light hypothesis. All that can be said is that the electro-magnetic theory of light indicates the possibility of a kind of light which like the X rays could not be refracted, and could penetrate opaque bodies. This is not saying much, and, it would not, we are sure, be difficult to say as much for some of the other theories. Sir G. Stokes declared himself to favour the transverse wave theory in a lecture which he some time ago delivered before the Victoria Institute, but in a postscript to this lecture published in *Nature* last week, he abandons this theory, and is now engaged working out another which he thinks will give a more complete explanation of the facts.

In America, the jet theory of the Röntgen rays appears to be most in favour. Tesla considers that the atoms or material particles composing the cathode stream are broken up into a finer form by impact against the anticathode, he says, in fact, that matter is broken up into ether, and that this reflected spray of newly manufactured ether constitutes the Röntgen rays. The Lenard rays he considers to be atoms that have passed through the interstices of the vacuum tube unbroken. This idea of breaking up the atoms into ether is rather crude for most peoples taste, and upsets our ideas about the conservation of matter. Tesla, however, is a skilled experimenter and his ideas are deserving of careful consideration. He considers that this jet theory best explains the constant ratio of the opacity to density which *cæteris paribus* is so characteristic of the action of the X rays on matter. He points out "an often noted fact which entirely disagrees with any theory of transverse vibrations, but can easily be explained on the assumption of material streams." The fact is thus described by Tesla: "When taking impressions at a small distance with a tube giving very intense rays, no shadow, unless a scarcely perceptible one, is obtained. Thus, for instance, the flesh and bones of the hand appear equally transparent. As the distance is gradually increased, it is found that the bones begin to cast a shadow while the flesh leaves no impression. At a still greater distance the shadow of the flesh appears, while that of bones grows deeper, and in this neighbourhood a place can be found at which the definition of the shadow is clearest. If the distance is still further continually increased the detail is lost, and finally only a vague shadow is perceptible, showing apparently the outline of the hand."

According to the view founded on the Helmholtz theory, this change in the relative opacities could only be due to a change of frequency; a supposition opposed to all the received notions of wave propagation.

Salvioni and other Italian physicists appear to favour the ether jet hypothesis, and we think the investigation of this hypothesis is likely to lead to much more satisfactory results than the transverse vibration theory.

We have seen recently a statement in a newspaper that an impression has been obtained of a coin placed on the side of the photographic plate turned away from the X ray tube. If this should be confirmed, it would tell strongly in favour of the jet theory.

In Germany, with the exception of Röntgen's longitudinal wave hypothesis, no theory appears to have acquired any prominence. The views about the cathode discharge are very different in Germany from those which are generally accepted here; and the views held about the Röntgen rays must depend very much on what we believe about the cathode rays. The mechanical effect of the cathode discharge appears to leave no doubt that there is a stream of material particles present. That these particles carry electrical charges is rendered more than doubtful by the well known experiment of Hertz, in which he demonstrated the absence of all electrostatical effects around the cathode stream. The experiments of Batelli and Garbasso have shown that there is some other kind of radiation in the cathode stream which is not deflected by a magnet, and resembles the X rays in almost every respect. These phenomena must all be explained by any satisfactory hypothesis of the X rays; and scientific men ought not to forget that there is no more fruitful source of fallacies than the tendency to form a judgment on insufficient evidence.

* *Amer. Jour. Science*, May, 1896.

CONSTRUCTION OF A TESLA-THOMSON HIGH FREQUENCY COIL.

By Prof. A. F. McKissick.

The following is a description, from the *American Electrician*, of the construction of a Tesla-Thomson high frequency coil, large enough to give a 5-inch spark and excite Röntgen ray tubes.

To excite the Tesla-Thomson coil, a high potential transformer of from 10,000 to 15,000 volts is necessary. The construction of this transformer will be first given. Fig. 1

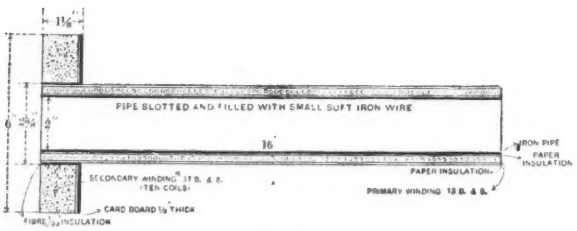


Fig. 1.

gives a partial cross-section of the transformer, which is made as follows:—A 2-inch iron pipe, 16 inches long, is slotted the whole length, either in a milling machine, planer or shaper. This slot need not be more than $\frac{1}{16}$th inch in width. The pipe is then insulated with ordinary wrapping paper to an outside diameter of $2\frac{1}{8}$ inches, shellac being freely used, and is then wound with No. 13 B. & S. double cotton-covered wire for its whole length (one layer). It is then covered with paper and shellaced until the outside diameter is $2\frac{3}{8}$ inches.

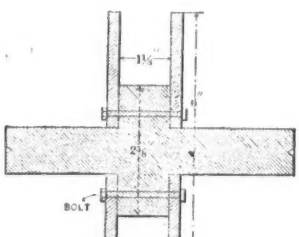


Fig. 2.

The next step is to fill the pipe with soft iron wires, No. 16 B. & S., each wire being cut 18 inches long. This completes the primary winding of the high tension transformer.

The secondary winding of this transformer consists of 10 coils wound in a form and thoroughly taped and insulated. This form is shown in fig. 2, and can be easily made of wood. The wire is wound in this form, shellaced, removed,

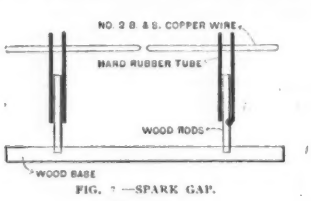


FIG. 7.—SPARK GAP.

Fig. 3.

taped and baked. These coils are then slipped over the primary winding, between each coil being placed a disc of cardboard $\frac{1}{8}$th inch thick, care being taken to connect the coils so that none will be in opposition.

The spark gap (see fig. 3) is made as shown in diagram. The copper wires fit rather close in the holes drilled through the hard rubber tubing, so that the length of gap can be adjusted with ease.

The condenser is made of ordinary 10-inch × 12-inch window glass. A sheet of tin foil 8 inches × 10 inches is pasted on one side of the glass with shellac, leaving a margin

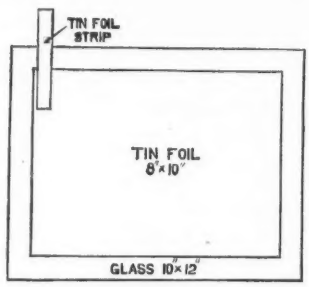


Fig. 4.

of 1 inch. (See fig. 4.) A strip of tin foil 2 inches wide is placed across one corner, this strip being placed alternately on each side. For each side of this condenser there should be 15 plates.

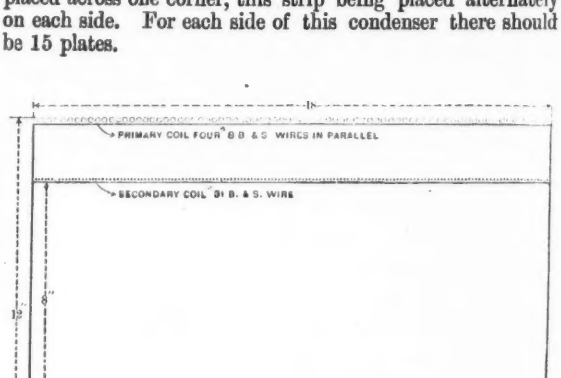


Fig. 5.

To build this condenser proceed as follows:—Place on a smooth surface a condenser plate with the connecting strip projecting on the right. On top of this plate place another piece of glass, 10 inches × 12 inches, that has no tin foil on it at all. Then place a condenser plate with the strip

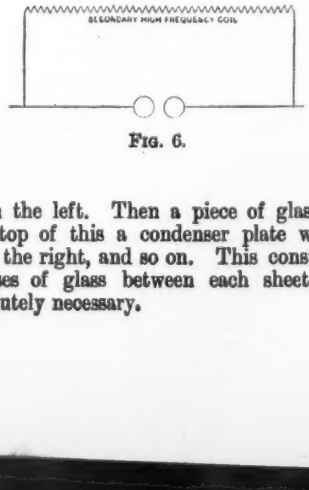


Fig. 6.

projecting on the left. Then a piece of glass without tin foil, and on top of this a condenser plate with the strip projecting on the right, and so on. This construction gives two thicknesses of glass between each sheet of tin foil, which is absolutely necessary.

The high frequency coil is made as follows:—Wind an 8-inch paper cylinder 18 inches long with No. 31 B. & S. double cotton-covered wire (or larger), leaving a margin at each end of about 1 inch. This is the secondary winding. The primary winding is placed on a 12-inch paper cylinder 18 inches long, and consists of 14 turns of four No. 8 B. & S. double cotton-covered wires in parallel. Each of these No. 8 wires is wound on separately, then the four ends at the beginning and ending are soldered together. Between wires of different polarity, as an extra precaution, two turns of cord are wound. The primary and secondary coils are then shellaced and baked. After being baked, the secondary coil is placed concentrically (see fig. 5) inside the primary and the connections as shown in fig. 6 then made.

THE ROASTING OF IRON ORES WITH A VIEW TO THEIR MAGNETIC CONCENTRATION.

The practice of roasting iron ores as a preliminary to their conversion into metal, is one which has usually been observed for the purpose of eliminating such elements as sulphur or arsenic, which would detrimentally influence the iron produced. It is only very recently that roasting processes have also been employed in order to render the iron ores magnetic, so that they can subsequently, by magnetic concentration, be freed from gangue—that is, from constituents not containing iron. It has gradually dawned upon iron smelters that the operation of roasting effects far more than they used to suppose it did, and that given certain conditions it is possible not only to eliminate volatile compounds by volatilisation or sublimation, or to expel water, carbonic anhydride, &c., but also to convert non-magnetic ores into ores which are magnetic, and thus render them suitable for magnetic concentration processes.

Our readers do not need to be informed respecting magnetic concentration; the process is extremely simple, and is one which is most usefully applied before the smelting proper is undertaken. The interesting thing to explain would be how it happens that an iron ore, after having been roasted under certain conditions, should have its physical properties so changed that it exhibits the phenomenon of magnetism. Why the presence of an atom more or less of oxygen in an iron oxide should determine whether it shall exhibit these magnetic properties or not, is a question so obscure that we are unable to answer it in the present state of our knowledge. All that we can be certain of is that by roasting such a substance as $Fe_6\ O_9$, which is non-magnetic, we can obtain $Fe_6\ O_8$ or $Fe_6\ O_7$, which are magnetic.

Prof. H. Wedding has recently compiled an extremely interesting paper on the roasting of iron ores, with a view to their magnetic concentration, and we are indebted for its publication to the issue of the *Contract Journal* for September 9th, 1896. Needless to say, the obscure question referred to in the preceding paragraph has not been grappled with. However, the paper is an extremely full one, and really comprises a fairly complete compendium of the subject. A great portion of it is occupied with the chemistry of roasting, and for this our readers must consult the original paper.

The magnetites, of course, do not require to be roasted, inasmuch as they can be submitted at once to magnetic concentration. Nevertheless, roasting is often resorted to in either case, partly for the purpose of facilitating its further reduction in size, for the magnetic treatment, by rendering it more easy to break down, and partly for the purpose of eliminating the sulphides it may contain. At a dull red heat in an oxidising flame, magnetite will lose its magnetic power, but will regain it when it is raised to a higher temperature. In practice, however, the artificially prepared magnetite does not behave so favourably as the native mineral.

By roasting spathic iron ores in a neutral atmosphere the "ignition" magnetic oxide, $Fe_6\ O_7$, is obtained, and by roasting in a moderately oxidising atmosphere, the magnetic oxide $Fe_6\ O_8$. If, however, the carbon dioxide is once eliminated, both these magnetic oxides pass readily under the action of the oxygen of the air into the non-magnetic ferric oxide, $Fe_6\ O_9$. If, therefore, it is desired to produce the magnetic oxide, the whole success depends on roasting with exclusion of air, or, if this is impossible, on reducing the air access to a minimum. It is possible, without endangering the magnetic character of the product, to roast spathic carbonates at temperatures as high as may be necessary to eliminate as far as possible the sulphur occurring in the spathic ores, as iron and copper pyrites, zinc, blende, &c. For the preparation of magnetic oxide from the spathic carbonate, no reducing roasting atmosphere is consequently necessary.

Magnetic oxides can be prepared from the ferric oxide of red hæmatites in two different ways: (1) By heating strongly in the absence of air. One atom of oxygen separates off in this way, and, indeed, by properly firing, two oxygen atoms may be eliminated — $Fe_6\ O_9 = Fe_6\ O_8 + O = Fe_6\ O_7 + 2\ O$. For this reduction of ferric oxide a relatively very high temperature is necessary, at which, if the red hæmatite contains a quarzose gangue, slag may readily form. In any case it is difficult, at the high temperatures at which this separation of oxygen takes place, to avoid a sintering, or even it may be fusion of the gangue with the ferric oxide, and the formation of an iron silicate. (2) The second method of preparing magnetic oxide from red hæmatites depends on the roasting of the ore under the action of reducing gases, of which at low temperatures hydrogen, and at higher temperatures carbon monoxide are most suitable in their action. To be certain, therefore, it is best to employ in the roasting a mixture of both these gases, that is to say, to roast with ordinary water gas.

Before the ferric oxide of the hydrated iron oxides (brown iron ores) can be reduced, the water must first be eliminated. The residue then behaves as red hæmatite would, but the reduction proceeds far more readily under the influence of reducing gases, owing to the more porous character of the ore after the elimination of the water. Laboratory experiments have shown that even from the iron oxides of the dehydrated brown iron ores, magnetic oxide may be prepared both by strongly heating with exclusion of air, and by heating gently in reducing gases. On the whole, for brown iron ores, the method in which use is made of reducing gases at a low temperature is most advantageous on economic grounds, owing to the saving of fuel.

Pyritic ores, before a reduction can take place, must first always be robbed of their sulphur contents, or at least mainly so. As in any case pyrites is subjected to an oxidising roasting for the purpose of obtaining sulphur dioxide from its sulphur contents, the residue is in practice always ferric oxide, and this ferric oxide behaves exactly as that of red hæmatite, except that it is a little more difficult to reduce, owing, perhaps, to the presence of some residual sulphur.

The size of the ore pieces to be roasted to magnetic oxide is not unimportant. Before all things, it is necessary, in order to obtain a good result, to have the pieces that are to be roasted as nearly as possible of the same size. It may be taken as a rule that the magnetisation takes place the more readily the more the ore is in the form of small, but solid, pieces which do not crumble up or fly into bits on roasting, since the gas can then readily pass through the interspaces, and the relatively small ore particles are rapidly converted into magnetic oxide right through their mass. A much larger size of the ore particles is disadvantageous, as for their conversion into the magnetic oxide too long a time is necessary, and since it is then uncertain whether this magnetisation has gone right through to the centres of these ore lumps. Phillips has very rightly pointed out, in opposition to the observations of Barton, that the magnetisation always takes place from the outside inwards, and never from the inside outwards.

Pulverulent or very small ore particles are excessively difficult to magnetise, since the passage of the gases through the small interstices is rendered very difficult, and the gases usually form small ways or channels, from which the conversion then begins. It is, therefore, very difficult to magnetise ores for magnetic preparation which have already been broken down very small, or are pulverulent. All such experiments which have been made, as, for instance, those at Allevard, have led to results which have not been altogether satisfactory, as the size of the pieces to be magnetised was much too small. More important than the actual size of the pieces is the necessity for having them under all circumstances of a similar size, and one cannot, therefore, pay too great attention to ensure, by twice passing through screens

before the magnetising roasting takes place, that all the ore pieces to be roasted have been brought to one and the same size.

One of the principal conditions for properly roasting iron ores into the magnetic state is the keeping of a right temperature in every part of the furnace. Since the Le Chatelier pyrometer is made in the form described by the author (*Stahl und Eisen*, 1895, September), all difficulty in controlling the temperature is obviated, and the instrument may unhesitatingly be relied upon for this purpose.

The magnetised ores, after roasting, are submitted to concentration, which may in the first instance be mechanical in character, to separate from each other the ore particles of different sizes, and then magnetic, or it may be magnetic from the very commencement.

This must be entirely dependent on the character of the ore as regards admixture of gangue and iron oxides. The finer the state into which the ore is brought for magnetic separation, the more satisfactory will the progress of that separation naturally be, and the better will be the yield. The fine state of the ore has, however, in spite of this, various drawbacks. In the first place, as has been mentioned above, the magnetisation is, as a rule, by no means regular, and in the second, such finely divided ores can only be added with advantage in quite small quantities to the blast-furnace charge, former experience in this direction placing this maximum at 12 per cent. All methods, too, of converting this fine ore again into larger lumps are too expensive to be, at least, generally, commercially satisfactory. If, therefore, the ore is to be used in blast-furnace practice such very small ore must, as far as possible, be avoided, and the size should be kept at about that of a hen's egg. On the other hand, small and even pulverulent ore may very well be utilised in the open hearth, and it has for this field of operations a very wide scope indeed, for the scrap which is now necessary for the conversion of the pig iron into ingot metal in the open hearth process is becoming year by year more difficult to obtain and more expensive to purchase, and it might very readily be entirely replaced by oxides. If the ores powder up readily on charging into the bath of pig iron, they may be enclosed in cases of sheet iron or paper (cartridges).

Very few ores are of themselves pure enough for the open-hearth process, and they cannot either be converted into an adequately pure form by mechanical concentration, so that there is scarcely any other way of purifying them which could prove itself commercially economical, except the method of magnetic concentration, which, if the ores are not magnetic, must be preceded by a magnetic roasting.

FAULTS IN DYNAMOS.

Armature Connections.

In this section will be discussed mistakes in armature connections. These, of course, are made at the factory, or more frequently at the repair shop, where the armature may be unfamiliar. At the factory errors are so seldom made, and the subsequent test is so searching, that it will hardly pay to test out an armature before assembling except to make a ground test; but when a local repair shop has rewound or repaired the armature, it is safer to know of its condition before putting it at work in the machine.

Mistakes are almost invariably at the commutator connections. Especially is this the case with drum armatures, for their winding is more confusing than that of the simple Gramme ring.

One of the most common errors, states a writer in the *American Electrician*, occurs with a winding arranged like that of fig. 1. A single wire emerges from the winding and passes down, connecting to a segment of the commutator. Where the windings and connections are bunched under a canvas head, less care is paid to symmetry, and where there are a large number of segments and connections, it is very easy to cross a pair of them as at A (fig. 1), the correct connection being shown at B.

Now, in a correctly connected winding, a current passing through it will traverse one-half of the wires in one direction and the other half in the other direction, as shown at B. Moreover, these halves must be bunched together; that is, all of the *up* conductors and all of the *down* conductors must be together. If an up conductor, such as 10 (A, fig. 1), is situated between two down conductors, something in the connections is wrong. In a four-pole machine, the conductors should be divided into four bands, and so on.

Such a mistake will cause intermittent sparking when the machine is in operation. That is, there will be sparks at the brushes, which will keep step with the revolutions of the armature. The bars at or near the improperly connected bar, according to the type of winding, are usually eaten away by this sparking, and thus easily located. Unfortunately, there are a number of other causes that produce intermittent sparking, and this effect cannot be taken as positive evidence of incorrect connection, although it may be grounds for strong suspicion.

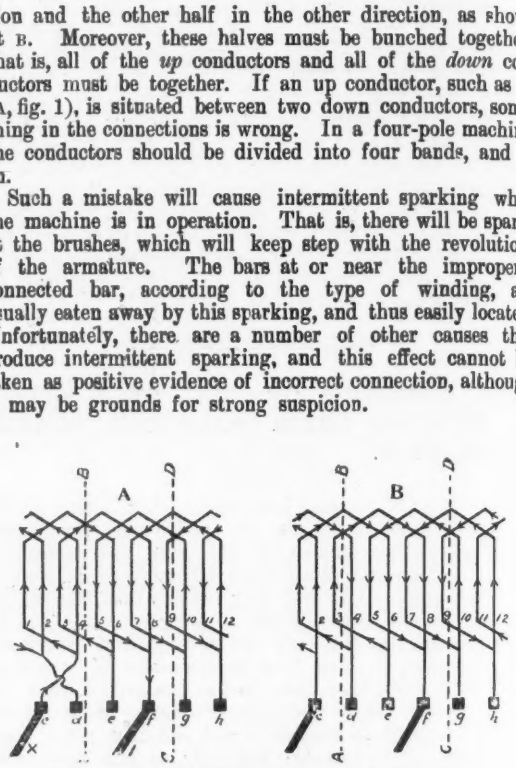


Fig. 1.—Faults in Drum Armature Connection.

To definitely establish the fact that an armature is improperly connected, the following method is convenient and sufficient. Prepare a frame of hard wood that can be tightly driven on to the shaft of the armature and only be moved thereon with considerable friction. In holes bored at suitable positions, mount the machine brush studs, and adjust the brushes to their normal position on the commutator. Support the armature on horses, so that it can readily be turned relatively to the frame. Pass a strong current through the armature, as strong as it will carry without overheating. Procure a flat, thin glass bottle

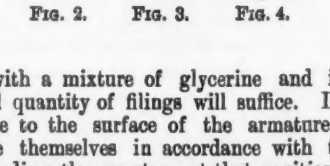


Fig. 2. Fig. 3. Fig. 4.

and fill it with a mixture of glycerine and iron filings. A very small quantity of filings will suffice. If this bottle be held close to the surface of the armature the filings will arrange themselves in accordance with the lines of force surrounding the armature at that position. For convenience we will use the notation of Prof. S. P. Thompson.

In figs. 2, 3, and 4, the small circles next the bottle represent wires perpendicular to the plane of the paper. Those with a dot in the centre indicate that the current is flowing toward the observer, while those with a cross show that the current is flowing away. It is convenient to consider the dot as the approaching point of an arrow, and the cross as the retreating tip. From what has been said there are obviously only so many places on the periphery of the armature, where there are two adjacent wires carrying currents in opposite directions as there are poles on the machine. If more than that number should be discovered, it would be proof positive of improper connections.

Now, if the bottle of glycerine and iron filings be held against the armature at such a point, the filings will arrange themselves as in fig. 2. At any other position on the armature they will arrange themselves as in fig. 4. A moment's experimenting with the bottle of filings will at once discover these positions of opposite current in adjacent wires. It will be seen that these appearances, like that of fig. 2, occur at

equi-distant positions. There are two of them if there are two poles, four if there are four poles, and so on, as previously indicated. But if among the wires carrying the current up there should be one carrying the current *down*, due to an incorrect connection, the filings when placed opposite such a point will assume a position such as that of fig. 3. Its unsymmetrical position with respect to the others, its different appearance as indicated by the filings, and its very existence, point conclusively to the error, and clearly indicate the cause.

In the case of fig. 1, it is well to note that *unless the brush is on one of the affected segments*, the incorrect connection will not be thus indicated, and the armature will test out correctly. Therefore the armature must be tested with the brushes on each segment in turn till there is no segment that has not been under a brush. If there are two brushes, the armature must be tested half as many times as there are commutator segments. If four brushes, one-fourth as many times as there are segments, and so on. The fact that the

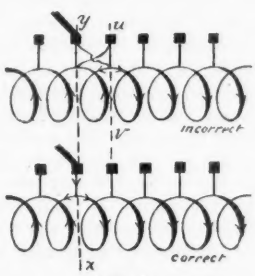
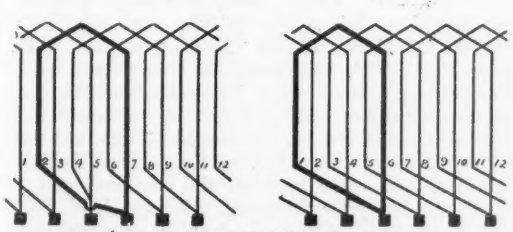


Fig. 5.

fault will not be indicated except when the brush is on the affected segment is a most convenient circumstance, as it not only detects, but locates the mistake. It is unfortunate that this condition does not obtain in all cases.

In the case of a ring armature, the winding of which is shown in fig. 5, such a misconnection would only have the effect of *shifting* the dividing line between the up and down conductors. It would not insert a down conductor among a lot of up ones, or *vice versâ*. Therefore, in any position of such an armature arranged as described, there will never be any more points of adjacent reverse current wires than there should be; but when the brush rests on one of the incorrectly connected segments, these positions will *not be equally spaced about the armature*.



Figs. 6 and 7.—Faults in Armature Connections.

In such a case the best way is to seek out the proper position of one of these places, and holding the bottle of glycerine there, slowly turn the armature. The instant the brush slips on to the affected segment, there will be a sudden movement of the filings, and they will shift along in the bottle.

In fact, this is a good way to test drum armatures also, for the wrongly connected conductor is always so close to the dividing line between the up and the down conductors, that it may be sought for there in almost all windings. Holding the bottle as indicated, at the instant that the brush slips on to the incorrectly connected segment, the second tuft will appear. This is much more convenient than trying the entire armature on so many segments; but unless the manipulator is familiar with the winding, it is never safe to pronounce the armature correctly connected unless this is done. In railway repair shops such methods as this will be found most convenient. Once the facilities are provided, the rest is very easy.

Armatures connected with long single wires leading from the windings to the segments, are rather less common than those in which two wires come to each segment. Such a winding is shown in fig. 6, and it will be seen at a glance that it is merely a modification of fig. 1.

Fig. 6 shows a common mistake. The commutator connectors of conductors 4 and 2 are interchanged.

In these simple figures the fault sticks out prominently; but in a complicated winding, a fault of the same nature is not so obvious. Such an armature placed in a machine would burn out the heavily shaded coil at once, for, at a glance, it will be seen to be short-circuited on itself. But it will also be noted that *it is not in electrical connection with any other part of the armature*. It is therefore most easily detected. On any *closed coil* winding each segment should ring up with any other, with a magneto bell. Such a misconnected segment will not do so.

Another mistake that is sometimes made is shown in fig. 7. Mere inspection will not disclose this trouble, for the armature usually *looks* all right unless the connections are minutely traced. Such an armature will refuse to excite, and a magneto bell will discover the fact that *none* of the commutator segments are in electrical connection with each other.

Such faults as these are best detected while winding. The winder should have his magneto at hand, and assure himself that he is right before he goes ahead. Particularly should he do so before he solders in his commutator terminals. It may be added that if such an armature as the last one is rotated in a separately excited field, it will instantly burn out on no load. In fact, no current can be drawn from it.

The foregoing remarks apply to closed coil types only.

SOME REFLECTIONS.

We are all becoming awake to the follies perpetrated under the guise of technical education, and our contemporary *Engineering* has an article all may read with profit, which conveys a good idea of the present state of affairs to which we have arrived by too much following along German lines. The instance of the London County Council's Chairman's eloquence on the advantage to the bricklayer of a chemical knowledge of clays is cited as an example of the idiocy of common ideas on technical education. We say by all means let every bricklayer have such knowledge, it will make him a better man and a better citizen, but the pursuit of entomology or a study of ferns will do this and will help him quite as much at his trade as a knowledge of clay. A brick is sometimes made of clay, it is true, and a bricklayer is made up of about 90 per cent. water, but we don't want a bricklayer to know anything about the clay. If we are using bricks and our bricklayer tells us they are badly burned and unfit for use that is all we want to know. We reject them. We don't care a straw that the clay was good. That is not our business. That belongs to the brickmaker. Let him attend to it. Now technical schools are not properly used to give men what we may term a liberal education. They are, properly speaking, narrow in their scope. It is their function to be narrow. *Engineering* very properly asks that an army should have leaders. Every private must not be a field-marshal or be given a smattering of higher strategy. Yet that is what technical schools have been doing, and in London they have cost half a million and are a charge of £120,000 per year, and only teach what might have been taught by evening classes in the Board school. We do not ourselves believe that foreign encroachments on our trade have been due either to lack of knowledge or inability on our part to compete in price. Sheer carelessness has done it. Take the case of the pipe order sent from Johannesburg to America. *Engineering* says it is due to the fact that no two pipe makers' productions were interchangeable. This is so. Wrought-

iron pipe is supposed to be to certain gauge. We believe Whitworth fixed this. We are told that one firm in Wednesbury uses it. But buy a lot of pipes from Russell's, Lloyd's, Stewarts, Wilson's, and others, and how do they interchange? Not at all. Why? Because of the idiotic idea that once they gain a customer they will be able to hold him fast. And if this is so, does it not cut both ways? Is it not hard to get in with fresh customers? And, as seen in the Johannesburg case, do not purchasers cry a plague on all your houses? We know where enquiries have gone abroad for this very reason. We have talked to pipe makers, but can get nothing out of them. Is not this of far greater importance than any amount of technical education? It is common sense that is wanted, an ability to understand what a customer requires, a determination to make exactly to order, and not to depart because "we thought this item was of no importance." We have seen manufacturers worry firms for months or years to secure an order, and then when the order was obtained to be weeks overdue with the delivery and the goods different from the sample specially supplied for an exact guidance.

Why cannot the technical schools take the matter up and teach to students the merits of commercial standard sizes? Probably because nine out of ten profesors have no real practical experience of the losses and inconveniences due to the absence of interchangeableness. The whole system of education is out of joint. Board schools have proved themselves absolutely useless for any purpose other than wasting money. Every domestic abigail may now be supposed as having experienced a Board school training. Will anyone say that there is the slightest improvement upon the pre-education days. If this be the case with the girls, is there any more to be hoped from their brothers. Not one little bit. The few will go ahead, but they would have done so in any case. The system of education is based on the desire to "put a quart of ale into a pint pot," and this is usually recognised as an impossibility. *Engineering* would regulate the supply to the capacity, and this would enable adequate provision to be made for the gallon measures which are now fain to be content with the average quart all round. No good ever did come to England from too much foreign interference, and in education as well as in trade German methods are equally reprehensible. The amount of ground lost in trade is by no means serious, and what has been lost has been lost from either want of sense or from either attempting to follow German lines in tricky practices or from want of oversight and the permission accorded to German makers of exporting German rubbish as English and getting German names stamped on honest English productions. Where we have lost ground as against American products we have done so purely because American methods have been good. They pack well, their goods are usually well made and they are interchangeable, and American effort, if sometimes exerted too strongly on the lines of economy of material, is not exerted, like much German science, in defeating the purposes of tests and in general questionable malpractices.

A NATIONAL SUBMARINE TELEGRAPH MEMORIAL.

Winchester House,
Old Broad Street, London, E.C.,
July 31st, 1896.

Sir,—It is proposed to form a committee for the purpose of inaugurating an International Memorial to commemorate the inception and extension of submarine telegraphy, the present—owing to the recent death of Sir John Pender, following soon after that of Sir James Anderson and Mr. Cyrus Field—being regarded as a most suitable time.

Owing to the efforts of those named and others, submarine telegraphy was established, and has remained almost exclusively a British enterprise and industry; and it occurs to me, in view of the great importance of the subject, that you may be willing to form one of the committee to carry out the projected memorial.

It is, of course, too early to forecast the ultimate shape which it should take; but the greater part of the fund will doubtless be applied to some national or international object, after providing perhaps a statue in some suitable situation.

Will you be so good as to let me hear from you as to this matter at your convenience, addressing your letter to Room No. 188, Winchester House, as above?

I am, yours faithfully,
(Signed) Tweeddale,
Chairman of the Eastern Telegraph Company, and of the Anglo-American Telegraph Company.

In addition to the above circular, the *Electrician*, of August 14th, states that the formation of a strong and representative committee is making considerable progress. Some of the influential names given are those who could not have any claim whatever to be called representative, so far as the subject of the memorial is concerned, as we do not think the judicial or political aspect of the inception and extension of submarine telegraphy is under consideration, nor is such an aspect to be desired if the object be solely to seek to commemorate a purely scientific and technical inception. We hope there will be enough members on the committee who will take an active part in directing its functions so far as to provide that personal sentiment does not take the place of common justice. We have before stated that the inception of submarine engineering, as applied to cable laying, does not owe anything to one man alone, and we think the following historical survey will show that the three names put forward by Lord Tweeddale have had little or nothing to do with that part of the work which should be immortalised. In justice to the Institution of Electrical Engineers, we should say the majority of the members must, by the nature of their work, be indifferent to the question under review, and the name of Dr. John Hopkinson on the committee carries with it no more weight than that of an individual. We think the history will show some of the names which should be perpetuated by a memorial, because of the prominent part which they took in the inception and extension of submarine communications. The earliest records of telegraphy under the water were made by Colonel Pasley in 1838, and Sömmering has often been credited as the originator of submarine telegraphy, based on his attempts in 1807 to ignite gunpowder. But setting this aside as possibly a myth, we find Sir William O'Shaughnessy in 1839 put a cable across the Hooghly River. Prof. Wheatstone in 1840 exhibited methods to telegraph across from Dover to Calais; and Prof. Morse laid down a wire in New York harbour in 1842, and proposed to lay a cable from Europe to America. In 1845 Mr. Ezra Cornell put a cable down in the Hudson River. Several trials were made between 1846 and 1848, and Mr. C. V. Walker in 1849 submerged a cable in the Channel. The English Channel Submarine Telegraph Company (which afterwards became the Submarine Telegraph Company), placed a cable connecting Dover and Calais in 1850, with which work Messrs. Brett, Wollaston, Reid, Crampton, Edwards, Willoughby Smith, and F. C. Webb were allied. Moreover, Mr. T. R. Crampton, C.E., Sir James Carmichael, and Lord de Manley were persistent money helpers of the scheme. This cable is still in existence. The third attempt to connect Dublin was successful in 1853, under Sir Charles Bright. It weighed 7 tons, and was laid in 150 fathoms of water. In 1858 England and Holland were connected, and other ports on the continent were joined during the few years following. Messrs. J. W. Brett and F. C. Webb struggled to lay the Spezia-Corsica and Sardinia-Bona cable in 1,600 to 1,800 fathoms, and the work was taken up by Mr. R. S. Newall on the retirement of Mr. J. W. Brett. The Black Sea cable was laid in 1855 by Messrs. Newall. The Cagliari-Malta and the Malta-Corfu cables were laid in 1857, and all these most important engineering endeavours which had practically solved the question of cable laying had been undertaken before the first Atlantic cable was attempted. The possibility of carrying electric currents through a great length of unbroken circuit (combined also with engineering difficulties) were faced, first, by Professor Wheatstone, and in 1852 Mr. F. N. Gisborne got Mr. Cyrus Field to become interested in the work of promotion. They together formed a small but strong syndicate, which Mr. J. W. Brett joined, and Messrs. Glass, Elliot & Co., then Messrs. Küper and Co., got an American steamer, the *James Adger*, and some 40 miles of cable was laid in 1855 between Cape Breton and Newfoundland. In 1856 this cable was completed.

Mr. Cyrus Field then came to England in 1856, and together with Mr. J. W. Brett and Sir Charles Bright, started the first Atlantic company. The profile of the Atlantic having been ascertained by Lieut. O. H. Berryman, U.S.N., and Commander Joseph Dayman, R.N., with a sounding machine of Lieut. Brooke, U.S.N., while Messrs. Bright & Whitehouse were carrying on experiments in London. Mr. Edward Bright was also connecting the landlines to Ventry and Bantry Bays, Ireland, to meet the Atlantic cable. Specimens of cable were made by Messrs. Glass, Elliot & Co., at that time. The British Government gave a guarantee of £14,000 a year, and promised vessels. £350,000 was needed, and this was found by merchants and shipowners in Liverpool, and its collection was partly due to the inspiriting addresses of Messrs. Field and Brett, who were not only strengthened in their efforts by the technical advice of Sir Charles Bright, but also by this gentleman, Mr. Joseph Hubback and Mr. Charles Pickering heading the Liverpool subscription list with £2,000 each. The board was formed by Messrs. Peabody, Gurney, Hankey, Lampson and Brown, of Liverpool, and the bulk of the shares were taken up by those holding stock in the Magnetic Telegraph Company, at the instigation of Messrs. E. and C. Bright, as manager and engineer respectively. Professor William Thomson (now Lord Kelvin) believed in the Atlantic cable, and made its working practicable by the invention of his galvanometer in 1857-58. Sir John Pender was then a director of the Magnetic Telegraph Company, and it is safe to say his name would have been a leading one if he had been concerned in the inception of cable telegraphy, but the object of the pioneers was to induce persons in all the large towns to equally participate in the subscription. We find, however, that under Messrs. Bright, Whitehouse, Thomson, Canning, Woodhouse, F. C. Webb, Clifford, de Sauty, Samuel Phillips, and W. E. Everett, U.S.N., that a fleet of vessels, the *Agamemnon*, *Niagara*, *Leopard*, *Susquehanna*, *Cyclops*, and the *Willing Maid*, commenced operations. We also know Mr. Charles Bright received a well-merited knighthood; Captains Preedy and Aldham got their C.B., and the rest got "ovations." The 1858 cable failed in October, owing to the use of high voltage. In 1857, Mr. Lionel Gisborne promoted the Red Sea and India Telegraph Company, and an attempt was made to lay the cable. Mr. Forde was the engineer, and Messrs. Siemens & Halske electricians, and Mr. Werner Siemens joined the expedition. We may at this point well accentuate the services of Messrs. Forde and Werner Siemens. On the Board of Trade Committee, formed for the purpose of considering the best methods of manufacturing, laying, and maintaining submarine telegraph cables, were Messrs. Stephenson, Galton, Wheatstone, Fairbairn, and Bidder, and representing the Atlantic Company were Messrs. Edwin and Latimer Clark, Varley and Seward. Galton was the chairman, and the sittings extended during 1859-60. Profs. Wheatstone, Thomson, and Messrs. Charles Bright, Whitehouse, Canning, Latimer Clark and C. W. Siemens, were examined, and the fundamental principles given by them hold good to-day, as do the tables made by Mr. Forde. In 1861 the formulation of standards and units was established, and a valuable paper on the subject by Messrs. Bright and Clark was given. Prof. Thomson got a committee together, and the members were Messrs. Williamson, Wheatstone, Thomson, Miller, Matthiessen, Charles Bright, Maxwell, C. W. Siemens, Balfour Stewart, C. F. Varley, Carey Foster, Latimer Clark, D. Forbes, Charles Hockin, Dr. Joule and Fleeming Jenkin; and the result was a system of electro-magnetic absolute units, from which are derived the ohm, ampere, farad, volt and coulomb, the nomenclature being suggested by Messrs. Bright and Clark. In 1859, on Bright's specification, we had the 1859 Malta-Alexandria cable, which had 1,200 miles of circuit. It was made by Messrs. Glass, Elliot & Co., Mr. H. C. Forde, engineer, and Messrs. Siemens, Halske & Co., electricians. Messrs. Canning, Clifford, and De Sauty, came into this work, and it was the first cable Mr. Willoughby Smith proposed to coat the central copper wire with compound. This cable having developed faults was replaced in 1868 by Messrs. Bright, Canning, and Willoughby Smith on behalf of the contractors. In 1860 Sir Charles Bright put down 365 knots successfully in the Mediterranean, some of it being in deep water—1,400 fathoms—between Barcelona and Port Mahon, and it was manufactured by Mr. W. T. Henley. The Toulon-Algiers and Algiers-Port Vendres cable was laid in 1860. It was designed by Sir Charles Bright, and made by Messrs. Glass and Elliot for the French Government. It was picked up in 1,300 to 1,400 fathoms, and finally completed by a new contract, taking Port Vendres as the starting point. It lasted till 1862. The Oran-Carthagena cable was made for the French Government by Messrs. Siemens and Halske, and after placing on board the cable steamer *Dix Décembré*, an unsuccessful attempt to lay it was made. The Indian cables, under the able director, Colonel Patrick Stewart, R.E., and Colonel Goldsmid, R.E., came on in 1859, and they were made by Messrs. Newall & Co. and W. T. Henley, under the guidance of the above gentlemen. Messrs. Bright and Clark, personally represented by Sir C. Bright, with Messrs. F. C. Webb, P. C. Laws, F. Lambert, and others, laid these cables; and they may be considered to have been the first which have held out. It was not till they were laid, and the success of cable laying and working practically assured that Atlantic work which had failed in 1858 can be seriously considered. The promotors had never ceased agitating. Messrs. Thomson & Varley between them assured the scientific success and working of long cables, and Mr. W. Reid had designed a method of testing core under pressure.

With regard to the 1865 cable, the first element needed to put life into it was the infusion of new blood, and Mr. Cyrus Field, for this purpose, interested the late Mr. Thomas Brassey, who at once recognised the national benefit to be derived from such an undertaking. The Telegraph Construction Company led off with a subscription of £100,000, and 10 others followed with £10,000. Mr. Gooch declared his willingness to increase his share to £20,000; but of all those subscribers, none can claim credit or honour equal to Mr. Brassey, who said he would stand in to the extent of £60,000, if needed. Mr. Bewley, of Dublin, already a large owner of Atlantic stock, declared his readiness to put down £20,000; but none were required to subscribe more than £10,000. Here are the names, arranged alphabetically: Barclay, Bewley, Brassey, Campbell, Elliot, Field, Glass, Gooch, Pender and Smith. There were besides 10 other minor subscribers.

The *Great Eastern* had Captain (afterwards Sir James) Anderson in command, and Staff Commander H. A. Moriarty, R.N., took an equally important position on the ship's books, viz., that of navigating officer. Some of the cable pioneers were on board. The cable machinery was fitted up and put on board by Messrs. Clifford & Canning, and Mr. Appold's type of brake formed a distinct feature of it. Mr. Willoughby Smith also came into the work; and, finally, we find the board of the Construction Company was composed of Messrs. Glass, Elliot, and Gooch, whilst Messrs. Thomson and Varley were there representing the interests of the Atlantic Company. The second attempt to lay a cable was successful, and by 1866 three cables connected this country with the United States of America.

At this period, and when the value of the labour which had been given towards the inception of submarine telegraphy was best known—being fresh in the minds of all—some of those most interested received public recognition. Mr. Curtis Lampson, the vice-chairman of the Atlantic Company, and Mr. Daniel Gooch, who held the same position in the Anglo Company, received a baronetcy, and Messrs. Thomson, Canning, and Glass were knighted.

The promotion of the laying of a direct submarine line to India and the Far East now comes under consideration. The first memorial to the British Government was signed by Messrs. Bevan, Gooch, McLean, Allan, Elliot, Halliday, Nicol, Rawson, and Stephenson. The engineers were Messrs. Bright and Clark. Mr. John Pender, a merchant, acted with Messrs. Glass, Elliot and Gooch, and they were instrumental in turning the well-known business of Messrs. Glass, Elliot & Co. into the aforementioned Telegraph Construction and Maintenance Company, by the large sums contributed by them, and by inducing other capitalists to join. The first members of the Company were Messrs. Anderson, Erlanger, Glover, Hay, Hornby, Rawson, and Wingfield, and their engineers were Messrs. Clark and Forde. In 1869, the *Great Eastern* left for the East with 2,375 knots of cable, and at this period it may be considered that the experience built up by Messrs. F. N. Gisborne, Bright, Canning, Clifford, Clark, Forde, Thomson, Werner and C. W. Siemens,

and others we have mentioned, made this extension eastwards —so far as the technical part was concerned—absolutely easy. The financial side was never in doubt, and the sources of traffic to repay capital outlay were more than apparent. Some of the early workers to whom any credit is due have died in comparative poverty, and a short while ago one was the recipient of a fund given by his *confrères*. This, then, is the brief history of submarine cable efforts, and if it is really agreed that some sort of monument (we suggest anything but a statue) is required to commemorate the inception and extension of submarine telegraphy, it would be a pity if the promoters of the scheme fail to recognise—as they show signs of doing—that it was only by the work of the scientific pioneers that it became an accomplished fact. In all cases of enterprises of this nature, it is generally understood that those taking part in the financial operations stand in solely for the possible profits accruing therefrom.

CORRESPONDENCE.

On Celluloid and Accumulators.

I have been disappointed to find that my queries on the above subject have not elicited a particle of information.

There is little doubt the battery makers could tell all about it if they would, but as many of them have erected large batteries in the recent past, in which celluloid was used exclusively, they are afraid to condemn their work by being too communicative, but would rather the unfortunate users should find it out—later on.

In a circular letter concerning renewals, the E.P.S. Company, referring to separators, say :—"And if these are found to be celluloid, we should strongly recommend that you exchange them for ebonite, as it is found that after some years' use it is not satisfactory to put in new plates with old celluloid separators."

Here is some practical instruction that shows the E.P.S. Company have the courage of their convictions.

Possibly the exchange is effected free of charge.

Do *new* plates and *old* separators disagree any worse than new plates and new separators, or old plates and old separators ?

Having to maintain a large battery that has passed through the teething, measles and whooping cough stages of battery existence, and is not in robust health, I want to know what is to be done with the celluloid.

What may I expect if I allow it to remain in use ?

If I have to turn it out at my expense I want some good reasons for doing so. Can some gentleman supply them ?

A. Cell.

[Mr. Crompton or Mr. Howell could say much on this subject.—Eds. Elec. Rev.]

A Problem in Electro-Dynamics.

It is not my intention to prolong the discussion on this interesting problem, but a personal explanation on one or two points is necessary.

It is said in the comments on my letter, that "according to Mr. Finlay, the flux inside the ring should be as dense as outside." This is incorrect. I know that it is quite easy to prove that the density is small, and, in fact, my sketch shows none, and it follows at once from the theory, if we assume that each line snaps across at a very rapid rate, and this is a natural assumption. If a bar conductor be placed along the axis of the ring, and perpendicular to the plane of the ring and moved along with it, then there will be as much E.M.F. set up in the conductor as if the ring were not there to "shield" it.

Regarding the ring transformer—fig. 2 is supposed to represent *my* explanation of the working of a transformer. This is also incorrect. The contracting and expanding of the lines of force do not take place to or from the centre of the ring ; each line may reasonably be considered to contract and expand to and from the middle of that turn on the ring which induces it, nor can it be reasonably assumed that once a line has expanded sufficiently to take up its position in the iron that it will expand further and leave the iron. If this be borne in mind, a figure very different from fig. 2 may be obtained.

I have been brought up on this "pabulum," and am practically engaged in constructing an electro-magnetic machine, which I hope may, with the aid of an arc lamp, throw light on the subject.

Archibald H. Finlay.

Holywood, co. Down.

The Telegraphist and the Tiger.

The following paragraph appeared in the *Westminster Gazette*, on the 15th inst. :—

The Tonquin mail advices report that a private in the telegraphic corps was carried off by a tiger at the station of Cao-Kienh, at the end of July. He was in the act of attaching the transmitter to the wire when a tiger bounded upon him and rushed away with him in its jaws. No trace of the poor fellow has since been found.—*Dalziel.*

Whether it was the act of attaching the transmitter, or transmitting the act on the wire, which aggravated the tiger, we should not care to state ; but it will be a shock to many when they learn that the tiger and its story has gone from the land of its birth.

C. St. Jacques.

London, *September 16th*, 1896.

BUSINESS NOTICES, &c.

Electrical Wares Exported.

Week Ending Sep. 15th, 1896.	£	s.
Alexandria. Teleg. mtl.	614	0
„ Teleph. mtl.	29	0
Amsterdam	115	0
Antigua	10	0
Antwerp...	20	0
Bombay	135	0
Brisbane	35	0
„ Teleph. mtl....	70	0
Calcutta	848	0
Cape Town	542	0
Colombo	13	0
„ Teleg. mtl. ...	27	0
Durban	198	0
East London	585	0
Fremantle	1,076	0
Ghent	10	0
Hamburg. Teleg. mtl.	321	0
Hong Kong	12	0
Kurrachee	75	0
Madras	40	0
Melbourne	103	0
„ Teleg. mtl.	283	0
Penang	29	0
Perth	85	0
Rangoon. Teleg. mtl....	15	0
Santos. Telepb. mtl. ...	32	0
Singapore. Teleg. mtl.	139	0
Stockholm	65	0
Sydney	596	0
Wellington	340	0
„ Teleph. mtl.	80	0
Yokohama	10	0
Total	£6,552	0

Week Ending Sep. 15th, 1895.	£	s.
Alexandria. Teleph. mtl.	50	0
Algoa Bay	358	0
Bilbao	73	0
Bombay	55	0
Brisbane	62	0
Buenos Ayres	24	0
Calcutta	33	0
„ Teleph. mtl. ...	79	0
Christiana. Teleg. cable	51	0
Colombo...	12	0
Delagoa Bay	66	0
East London	262	0
Gothenburg	15	0
„ Te'eg. mtl.	90	0
Hamburg. Teleg. mtl.	220	0
Helingsfors. Teleg. wire	119	0
Launceston	28	0
Marseilles. Teleg. mtl.	71	0
Melbourne	22	0
„ Teleg. mtl.	328	0
Port Natal	284	0
Rio Janeiro. Teleg. mtl.	893	0
Rotterdam. Teleph. mtl.	142	0
Santos	44	0
Shanghai	14	0
„ Teleg. mtl. ...	19	0
Singapore. Teleg. mtl.	79	0
Stockholm. Teleg. wire	62	0
Sydney	217	0
Wellington	315	0
Total	£4,087	0

Foreign Goods Transhipped.

	£	s.
Melbourne	8	0
Stockholm. Teleph. mtl.	8	0
Total	£16	0

	£	s.
Boulogne	44	0

Agency.—We are informed that Messrs. Connolly Bros., of Blackley, Manchester, have appointed the United Asbestos Company, of 93, Bothwell Street, Glasgow, their agents for the sale of insulated wire and cables, &c., in Scotland. A stock will be kept at that address.

Bankruptcy Proceedings.—A meeting of creditors *re* Bennett and Druce *(in chancery)* was held at the office of Mr. James Todd, the receiver and manager, Preston. The creditors present represented £1,006 odd out of £1,304 owing. A balance-sheet was placed before the meeting showing the position of the partnership

estate, and it was explained that the assets were being realised and the business worked out by Mr. Todd under the direction and supervision of the Court of Chancery. The meeting unanimously agreed that the realisation should be proceeded with.

Liquidation Notice.—A general meeting of the Fowler-Waring Cables Company, Limited, is to be held on Friday, October 16th, at 1 o'clock p.m., at 32, Victoria Street, Westminster, S.W., for the purpose of having an account of the winding-up laid before it by the liquidator.

Dissolution of Partnerships.—Messrs. J. A. Russell, R. F. Barrett-Lennard and J. R. Willcockson, hitherto trading as electrical engineers and art metal workers at 27a, Gloucester Street, Bloomsbury, E.C., have dissolved partnership, so far as concerns Mr. Russell. Mr. Willcockson will attend to the late firm's debts.

Messrs. W. J. Curtis and F. Shakespeare Hanning, carrying on business as electrical and general engineers at 6, King Street, Wolverhampton, under the style of Curtis, Hanning and Co., have dissolved partnership (as from August 1st) by mutual consent. Mr. W. J. Curtis will continue the business under the style of Curtis & Co.

Business Announcement.—Messrs. Wm. Whitehouse and Co., electric light fittings manufacturers, of Empire Works, Brueton Street, Birmingham, announce that Mr. Charles J. Tansley has ceased to represent them, and that Mr. H. C. Harold will in future represent them in London at 59, Holborn Viaduct, where their fittings showroom is situated.

Catalogue.—Another red book in the way of catalogues has been issued, this one taking for its subject the goods of Mr. G. Braulik. It is divided into six sections, one dealing with electric bells, batteries, accumulators, lamps, and accessories, another with telephone receivers, microphones, telephones, switches, and telephone accessories. A third section contains particulars of electro-medical apparatus, also switchboards, transformers, small electric light plant, &c.; another deals with telegraph instruments, galvanometers, lightning arresters, &c. The last section is devoted to electric light wires, incandescent lamps, measuring instruments, dynamos, motors, steam, gas, and oil engines, cooking and heating apparatus, and a hundred and one other things of equal interest to buyers and dealers in electric light apparatus and fittings. Arc lamps are, of course, in evidence. The book consists of several hundred pages, and abounds in illustrations. The sections are bound together in thick red cloth covers, making a neat catalogue of the whole.

Change of Address.—The Improved Electric Glow Lamp Company, Limited, has removed from No. 103 to 97, Queen Victoria Street, E.C. Mr. S. A. Bartlett is the secretary.

Magnet Forgings.—From Mr. Robert Jenkins we understand that the large increase in the demand for forged magnets for continuous current dynamos has compelled the Magnet Forge to add a 2,000-ton hydraulic press to their present plant, and two more furnaces. They will now be able to turn out magnet limbs over 50 inches wide; indeed, the plant is constructed to make, if necessary, larger magnets than have ever yet been used in the construction of continuous current dynamos. The plant, which was designed and erected by Messrs. Brown Bros. & Co., of Edinburgh, is principally intended to supply large magnets for central station work.

Partnership Notice.—Mr. R. F. Barrett Lennard has taken over Mr. J. A. Russell's share in the business of Russell and Lennard, and all existing contracts. Pending amalgamation with the Electrical Installation Company, Mr. Barrett Lennard will carry on business in his own name at 135, Victoria Street, S.W.

Price Lists.—Mons. A. Gandillon, of Senlis (Oise) sends us a list which describes a variety of machinery and apparatus manufactured by him, including turbines and dynamos, on the Gandillon and Vigreux system, also pumps, boilers, &c. Illustrations and prices are given.

Messrs. W. M. Still & Co. supply the "Still" incandescent electric lamps of all styles, shapes and sizes. They have issued a list.

Stewart Electrical Syndicate, Limited.—The above is the title of a new concern organised to do a general business as dealers in electrical supplies, with particular reference to import and export trade. Offices are located at 103, New Oxford Street, London, W.C. They handle the "Pioneer" incandescent arc lamp, burning 100 to 150 hours on 100-volt circuit, incandescent lamps made at one of the largest American factories, and the new Thompson-Ryan dynamo, which possesses the peculiarity of having a fixed point of commutation, thus obviating all necessity of shifting brushes under changes of load. The managing director, Mr. W. N. Stewart, is a well-known American electrician, who was associated with the foreign business of Mr. Edison for many years, and who has for the past five years been a general agent of the Siemens & Halske Electric Company, of America. Mr. Stewart's investigations on the high voltage lamp question have been frequently referred to in the technical press, and the new concern will pay particular attention to this branch of the business.

Testing for Gas in Street Boxes.—We have received a pamphlet devoted to the new Clowes-Redwood portable testing apparatus, which has been specially devised for the purpose of making correct and reliable tests *in situ* of the atmosphere in street boxes and culverts for the detection of leakages from gas mains. We understand that this testing apparatus, which was mentioned in our issue for February 1st, 1895, is now being used by the following companies:—The City of London Electric Lighting Company, Leicester Corporation Electric Lighting Works, Edinburgh Corporation Electric Lighting Works, Sheffield United Gas and Electric Lighting Company, and a number of London and provincial gas companies, and are understood to be giving every satisfaction. The apparatus is supplied by Messrs. W. J. Fraser and Co., of London.

Theft.—Charles Otter, when fitting up 20, Lancaster Gate, Hyde Park, W., stole goods to the value of £28. Pleaded guilty, and Mr. Bennett, at Marylebone Police Court, committed him for trial.

The National Telephone Company, Limited.—The action, Everitt *v.* the National Telephone Company, Limited, came before Mr. Justice Chitty (sitting as Vacation Judge) in the Chancery Division of the High Court of Justice on Wednesday, in the form of a motion to restrain the erection of telephone poles by the defendants. It appeared that a few days previously his Lordship in Chambers had granted an injunction, and on Wednesday counsel on both sides intimated their agreement to the continuation for a week of that injunction. On the same day (Wednesday) it transpired that an interim injunction had been granted by Mr. Justice Chitty against the defendant company in favour of the Callender Bitumen Telegraph and Waterproof Company, Limited, who had moved for an order to restrain the defendants from interference with plaintiff's telephonic apparatus. Under these circumstances there was an agreement between parties to the postponement of the motion until the next sittings of the Court, the defendants meanwhile giving an undertaking in the terms of the interim order.

Water Power.—Messrs. Carrick & Ritchie have issued a new list of their improved turbines and other motors for the utilisation of water power. Tables of powers and prices of "Waverley" turbines for various falls are accompanied by illustrations of the machine. Other items of the catalogue are the "Girard" turbine, combined turbine and dynamo, Pelton water-wheels. Some comments on the measurement of water power and the fixing of turbines add interest to the list.

ELECTRIC LIGHTING NOTES.

Alderley Edge.—At the last Council meeting, the Clerk stated that he had received a letter from Mr. S. V. Clirehugh, consulting engineer, Manchester, enclosing a cheque for £300 to cover the amount expended by the Council in obtaining the provisional order for electric lighting. The cheque, Mr. Clirehugh pointed out, was to be cashed only on the understanding that the deed of transfer was sealed by the Council, and that the consent of the Board of Trade had been received by the Council in pursuance of their agreement. The Clerk stated that a letter had been received from the Board of Trade stating that they were unable to proceed with the draft deed of transfer until they were satisfied with the financial position of the transferees. The Council resolved that the Board of Trade be informed of the receipt of the cheque, and assured that the work would be carried out in accordance with the provisional order.

Bath.—The Electric Light Committee has considered Mr. Hammond's report on the subject of extensions to the system. The tenders for the lamps and posts are said by a local paper to have ranged from £2,224 to £3,545; for engine and plant, from £7,828 to £11,512; for steam boiler, from £1,892 to £2,742; and for the laying of mains, from £6,169 to £12,424. Eight firms tendered for the supply of lamps and posts, and so far as this portion of the work is concerned each firm will be invited to send two specimens of each in order that a proper idea may be obtained as to their fitness. For the steam boiler the committee decided to recommend the tender of Messrs. Babcock & Wilcox, of Glasgow, at £2,462; and for engine and plant, that of the Electric Construction Company, London, at £8,364. For the work of laying new mains the British Insulated Company and Callender's, of London, ran very close, the former's tender being £8,015, and the latter's £7,985. It is understood that between these two firms the committee came to no definite decision, the firm sending the higher tender making a far larger allowance for boxes. For the supply of a large crane the committee decided to recommend the acceptance of the tender of Messrs. Stothert and Pitt, at £350. This matter is referred to under "Contracts Closed."

Bedford.—Applications for current continue to come in satisfactorily, the number of new lamps required being equal to 1,000 of 8 C.P., and these will be connected before the winter commences. The Electric Light Committee cannot see its way to extend the mains in St. Michael's Road yet.

The estimates for the next half-year include:—Expenditure—Public lighting: Gas, £700; electricity, £430; electric lighting department, £985. Receipts (electric lighting, private), £1,200; (ditto public), £430.

Birkenhead.—The electric light has been turned on in the Town Hall, and the public supply commenced. The mains have been laid in Hamilton Street, Hamilton Square, Market Street, Grange Road, and other main throughfares included in the compulsory area.

At the last Council meeting it was stated that the expenditure up to the present was £1,576 for land, and £14,440 for works and plant, making a total of about £16,000. There were various other commitments of the Corporation that would probably bring the total expenditure to something over £21,000. The expenditure, therefore, would exceed the estimate, but it was hoped the excess would not be abnormal. With regard to the installation in the Town Hall, an expenditure of £1,500 had been sanctioned, and the expense under this head would not exceed, perhaps not reach, £1,200.

Birmingham.—The Birmingham and Midland Institute is now lighted electrically.

Bristol.—The tenders for additions to the central station building, which included the works in connection with piling the river wall and the foundations, as well as the superstructure, were dealt with by the Electric Light Committee last Friday, and subject to the approval of the Council, and to the usual conditions, the tender of Mr. Frederick Martin was accepted. The following is a list of the tenders:—

Edward Walters, Bristol	£23,561
J. Davis, Bristol	19,980
John Perkins, Bristol	19,600
J. Durnford & Son, Bristol	19,370
William Cowlin & Son, Bristol	18,940
George Henry Wilkins, Bristol	18,898
A. Krauss, Bristol	18,855
Wilkins & Gosling, Bristol	18,557
C. A. Hayes, Bristol	18,251
J. Perrott, Bristol	17,750
R. Wilkins & Sons, Bristol	17,471
F. Martin, St. George (accepted)	16,725

The engineer reported that the fourth large engine and alternator had arrived, and was in process of being fixed.

Blackpool.—The Primitive Methodist Chapel is to be lighted electrically, the contract for the work being in the hands of Messrs. Simpson, of Hapton.

Chelsea.—The Surveyor's annual report to the Vestry gives the following particulars *re* electric lighting in the district:—The number of houses in Chelsea lighted by electricity for the last three years was as follows:—

	1893-4.	1894-5.	1895-6.
Chelsea Electricity Supply Company	500	598	777
London Electric Supply Corporation	6	9 (?)	No information.

The Chelsea Electricity Supply Company, as now extended, have area of supply throughout the whole of the home district of Chelsea, by adding to their district the whole of the parish west of Beaufort Street. The London Electric Supply Corporation have not carried out any further extensions during the past year. *Pressure Records.*—I have from time to time examined the records kept by the Chelsea Electricity Supply Company, and find that they still maintain a constant pressure, and the voltmeter fixed in my office generally stands at 100 volts. As the London Electric Supply Corporation do not appear to keep a separate record for the Chelsea circuit, I have not examined their records. *Town Hall*—The Upper Hall has now been fitted up with electric light.

Cork.—The tenders received for the transfer of the provisional order have been opened and referred to the Electric Light Committee.

Coventry.—The Local Government Board has sanctioned a £13,000 loan for electric lighting.

Douglas (I.O.M.).—The Town Council had a long discussion about the electric light last week.

Five guineas is to be spent in order to obtain certain preliminary information and approximate estimates from an expert on the subject of electric lighting.

Dover.—The incandescent electric lamps on the sea front are to be kept alight nightly until the end of the present month.

The lighting of Biggin Street and Cannon Street is receiving attention. A committee is considering the matter.

Edinburgh.—The estimates of the borough treasurer for the year 1896-7 stated by him at last Monday's special Council meeting, show that the increase in the charge for public electric lighting is almost £4,000. "In fact," said the treasurer, "we will be paying for the public electric light this year a sum of about ¾d. per £1."

Fleetwood.—In connection with the proposed transfer of the provisional order, the District Council has resolved to arrange an interview between the Special Committee and Dr. Hopkinson with reference to the supply of electrical energy in the district.

Fulham.—The report on electric lighting and dust destruction recently submitted by Mr. Medhurst has been looked into by the Electric Light Committee, who propose applying for a provisional order, but have not committed themselves to anything beyond that. It is said they are not very enthusiastic in regard to the matter.

Glasgow.—The Electric Lighting Committee has just placed orders for electric light cable with Messrs. Callender's Company, the British Insulated Wire Company, and the India Rubber Company of Silvertown. This is required for extensions.

Guildford.—The Town Council is very displeased with the annoyance caused by the firm which is laying the electric light cables not putting the paving right at once, and the Town Clerk is in communication with the firm in question.

Leeds.—The Corporation has passed plans for the erection of a new hotel, to be named the Hôtel Métropole, which will be lighted throughout electrically, and have a complete telephone installation.

London.—St. Alban Church, Holborn, is closed for the purpose of introducing the electric light and other improvements. The electric light is being installed by the Tayler Smith Electric Company, Limited.

Lowestoft.—Messrs. Taylor & Field and Mr. F. W. Stevens recently wrote to the Council *re* electric lighting, but the Council has replied that the matter stands deferred for the present.

Morecambe.—The District Council has resolved that the sum of £26,000 be borrowed upon security of the general district rate for the purpose of defraying the expenses of purchasing the plant and machinery of the Morecambe Electric Light and Power Company, Limited, according to the terms of the agreement between the Council and the company.

Northwich.—A company has been formed known as the Northwich (Cheshire) Electric Supply Company, with a capital of £10,000, in £5 shares. It is understood that the central station is to be erected near the Winnington Chemical Works, and the motive power to be used is Mond's patent producer gas.

Norwich.—Prince's Street Congregational Church is now lighted throughout electrically. Eight brass pendants, with clusters of five lamps, light the centre of the church, the aisles having smaller clusters.

Nottingham.—On business premises where more than fifty lights are required, many private firms are putting down their own electric light plant, and trade in this direction is, according to the *Daily Press* fairly brisk in Nottingham. The general demand for gas engines for this purpose is so large at the present time that gas engine makers cannot deliver under five or six months, instead of as many days, as was the case not long ago. Electric motors are also being very largely used, one local firm alone driving some five or six hundred sewing machines by this power.

Russia.—Mr. Vice-Consul Woodhouse, in a report to the Foreign Office on the trade of Nicolaieff, says: "Several proposals have been made to the municipality by different firms for the erection of electric plant on the conditions of lighting certain main streets, and of furnishing power at low rates for lighting other streets of the town," with the right of supplying shops and private houses. As usual many difficulties have been raised, and for the moment the question seems to be as far as ever from being solved.

Sheffield.—Mr. S. V. Clirehugh, of Manchester, has prepared the specifications, and is superintending the work of fitting up the Cutlers' Hall.

Southampton.—The Local Government Board has approved of the purchase of the electric lighting undertaking by the Corporation of Southampton, and sanctioned the borrowing of £54,000 for the purchase.

Stirling.—The ratepayers are kicking against the Police Commission's delay in introducing the electric light, under the provisional order secured recently.

The Royal Aquarium.—An extensive electric lighting plant is now being installed at the Royal Aquarium, Westminster. In laying out his plans the engineer, Mr. G. C. Fricker, is providing against every possible contingency by a system of duplicate machinery and multiple circuits, the lamps being placed so far as practicable alternately on each. This precaution is one which is also adopted by him in the extensive lighting of the Earl's Court Exhibition. At the Aquarium there will be two locomotive boilers, each capable of evaporating about 1,800 lbs. weight of water per hour; two vertical high speed engines, each indicating 60 horse-power; two 30 kilowatt dynamos; 28 2,000-C.P. arc lamps, and about 400 incandescent lamps of various candle-power. The whole installation is to be ready for the great Chrysanthemum Show on November 3rd.

Windsor.—Good progress is being made with the new central station in Peascod Street for the Windsor Electrical Installation Company. The foundations have been laid of the chimney shaft. The erection of the boiler house engine room, and battery room is also being proceeded with.

Withington.—The question of electric lighting has been under consideration for some time, and local feeling is well in favour of a scheme. The Council has been approached by the gas Committee of the Manchester Corporation with a view to extending the Manchester mains into the district, and has also received applications from firms desirous of undertaking the supply. A special meeting was held yesterday to consider the matter.

Yarmouth.—The Electric Light Committee has considered tenders for coal for the electric lighting station for 12 months, and that of Mr. E. V. Sterry at 14s. 2d. being the lowest, a 10-ton sample has been ordered. There are now 186 customers connected with the supply, using 9,052 lamps. The income in August was £265 0s. 8d., and the expenditure £179 16s. 9d., leaving £85 3s. 11d. towards capital and interest charges, which amount to £130 per annum.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Altrincham.—The District Council held meetings last week to consider two schemes for local tramways which were proposed by Manchester promoters. One proposes electric tramways.

Coventry.—The Coventry and District Electric Tramways Co., Ltd., have decided to apply to Parliament for additional powers so as to enable them to make important extensions of their line. At present the Company, who use the overhead supply system, run a successful service from Coventry to Bedworth, a distance of six miles. The proposed extensions will open up traffic in two other directions to the outskirts of the city.

Dublin.—The Dublin and Lucan Steam Tramway Co. is seeking power to work its line, now in course of construction, by electricity on the overhead trolley system or otherwise, or by other mechanical power; and for that purpose to purchase land for the erection of power house, to erect poles, &c., &c., also to issue £12,000 new preference stock and enter into contracts for the execution of the said electric works.

Portsmouth.—Last week the Town Council had under consideration a report from a special committee, who recommended that the Town Clerk be instructed to give the requisite notices of the intention to apply for Parliamentary power to acquire the lines of the tramway company, it being pointed out that should no definite agreement be arrived at with the company, or should the Council not approve the terms which might be submitted to them for approval, the proceedings need not be carried on. Alderman G. Ellis, chairman of the committee and also of the electric lighting committee, in moving the adoption of the report, gave elaborate statistics to show that the purchase of tramways and then leasing them to the company, and the supply of the electric current for working the cars, as proposed, would yield a large sum to the local exchequer. He combated the objections that were subsequently raised, but eventually, in deference to the wish of the Council, withdrew the report.

TELEGRAPH AND TELEPHONE NOTES.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired.
Brest-St. Pierre (1869, Anglo)	April 6th, 1895 ...	...
Puerto Plata-Martinique ...	Dec. 19th, 1895 ...	...
Monte Alegre-Santarem ...	May 5th, 1896 ...	...
Para-Maranham	Aug. 6th, 1896 ...	...
Bahia-Rio de Janeiro ...	Sept. 4th, 1896 ...	...
Penang-Medan	Sept. 7th, 1896 ...	...
Loanda-Benguela	Sept. 13th, 1896 ...	...
Landlines.		
Trans-Continental line beyond Masol (Mashonaland)	March 12th, 1896 ...	...
Cartagena-Barranquilla(Columbia)	July 4th, 1896 ...	...
Salisbury-Umtali (cutting off communication with Beira)	July 10th, 1896 ...	...
Saigon-Bangkok	Sept. 10th, 1896 ...	Sept. 11th, 1896
	Sept. 15th, 1896 ...	Sept. 15th, 1896
Siberian lines between Tomsk and Krosnoiarsk	Sept. 12th, 1896 ...	Sept. 13th, 1896

Telegraph Material in New Zealand.—The imports of telegraph material into New Zealand during last year amounted to £14,655, as compared with only £6,427 in 1894.

The New York-Hayti Cable.—The *Royal Standard*, Turks Island, of August 22nd, contains the following:—"On Tuesday last the French cable-tank ss. *François Arago* was seen in the offing manœuvring in the Turks Islands Passage. The ship was boarded by pilot F. Trott, who reports the taking of a series of soundings through the Passage, and the placing of buoys off the south end of Great Sand Cay. W. S. Jones, Esq., the French Consular Agent, tells us this ship may be expected to pass by in a few days engaged in laying the cable from Hayti to a point a little north of Grand Turk, where the end will be buoyed pending the arrival of the ship to lay the length from New York to this island. A Government notice in another column forbids any person interfering with the buoys laid down. For years this community has been anxiously awaiting promised cable intercourse with the outside world, and though all hope and confidence in the extension of the Halifax and Bermuda cable has not been lost, the action of the New York-Hayti Cable Company in passing us by almost within a stone's throw seems like the irony of fate."

The Telegraph Wire Export Trade.—A fairly active tone was noticeable last month in the export trade in this country in telegraph wire and apparatus connected therewith, the return showing a satisfactory increase over both the preceding month and the corresponding month of last year, as will be seen from the following figures:—July, 1896, £53,139; August, 1896, £65,176; August, 1895, £29,488. The returns for the eight months ending with August last show that the exports during that period have attained an aggregate value of £461,578 as [compared with only £338,169 in the corresponding period of 1895, but with no less than £1,254,774 in the first eight months of 1894.

CONTRACTS OPEN AND CLOSED.

OPEN.

Belgium.—October 28th. The Société Nationale des Chemins de Fer Vicinaux, in Brussels, is inviting tenders for the conversion of about 23 kilometres of "Vicinal" railways in the Charleroi district, into electric lines on the overhead conductor system. Particulars may be had for 1 fr. from, and tenders to be sent to, the Société Nationale des Chemins de Fer Vicinaux, 26, Rue de la Science, Brussels.

Belgium.—Tenders are at present being invited by the Belgian State Railway authorities in Brussels for the supply and erection of all the necessary plant required for a self-contained installation of electric lighting at the railway station at Arlon, for the lighting of the railway station offices, locomotive and waggon shops, locomotive shed, &c. Tenders are to be sent to the Bourse, Brussels, where particulars may be obtained. The date of the adjudication has not yet been fixed.

Bermondsey.—September 23rd. The Vestry of St. Mary Magdalen invite tenders for a report on the question of electric lighting and dust destructors. Information can be obtained at the Town Hall, Spa Road, S.E.

Edinburgh.—September 22nd. Tenders are invited by the Corporation for coal hoist, gantry, and capstan; coal hoppers, measuring gear, and shoots; also hauling gear in coal store for the electric supply station.

Edinburgh.—September 22nd. Tenders are wanted for the wiring of the Burgh Assessments Office, High Street. Particulars from the resident electrical engineer, 5, Dewar Place.

France.—October 1st. Tenders are invited for the supply of 594 tons of copper wire and 257,500 porcelain insulators. Tenders to be sent to the Sous-Secretariat d'Etat des Postes et des Telegraphes, Rue de Grenelle 103, Paris.

France.—September 24th. Tenders are wanted for the supply of a quantity of gutta-percha insulated telegraph cables, in two lots. Tenders to be sent to the Sous-Secretariat d'Etat des Postes et des Telegraphes, Rue de Grenelle 103, Paris.

France.—September 26th. Tenders are being invited for the supply and fitting up of pneumatic pipe lines in the French capital. Tenders to be directed to the Sous-Secretariat, d'Etat des Postes et des Telegraphes, Rue de Grenelle 103, Paris.

Italy.—The Italian Naval authorities at Spezia have just invited tenders for the supply of a quantity of miscellaneous electrical fittings.

Madras.—Nov. 11th. Lieut. Col. C. C. Rawson (in charge Consulting Architects' Division) invites tenders for the lighting by electricity of Government House, Madras, including the banqueting hall and the A.D.C.'s bungalow: also for the lighting of Government House, Guindy, including the Military Secretary's bungalow. Particulars to be obtained on application to the Consulting Architect to the Government of Madras, Chepauk, Madras.

Madrid.—October 8th. The Secretary of State for Foreign Affairs learns from her Majesty's Ambassador at Madrid that the Spanish Government have invited tenders for the construction and working of a telephone system in Mayagüez in Porto Rico. October 8th is the date fixed for the consideration of tenders, and such particulars as her Majesty's Government have received may be inspected at the Commercial Department of the Foreign Office between the hours of 11 and 6 daily.

Morley.—October 14th. From our "Official Notices" particulars may be obtained of boilers, engines, dynamos, alternators, &c., for which the Electric Light Committee invites tenders.

South Africa.—October 1st. The Municipal Authorities of Bloemfontein are inviting tenders for supplying and laying down a complete electric lighting installation for the town. Tenderers are to submit a complete description, with plans and specifications, of their proposed scheme to W. A. Koller, Town Clerk, Bloemfontein, Orange Free State.

CLOSED.

Bath.—The Electric Lighting Committee on Monday considered Mr. Robert Hammond's Report on the tenders recently received for the extension of the electricity works about to be

acquired by the Corporation. Mr. Hammond's recommendations were as follows:—

Boiler House Plant (Babcock Boilers)—	
Electric Construction Company	£2,462
Engine House Plant (Fly-wheel Alternators)—	
Electric Construction Company	8,364
Underground Work—	
Callender's Cable and Construction Company (Cables)	7,985
Electric Construction Company (Converters).. ..	470
Overhead Travelling Crane—	
Stothert and Pitt	350
	£19,631

With regard to the arc lamps and posts the tenders varied from £2,224 to £3,545, and Mr. Hammond recommended that each tenderer should erect a sample lamp at Bath which, working for two months, would give the committee an excellent opportunity of deciding for themselves which maker should secure the preference.

It was unanimously decided to adopt Mr. Hammond's report in its entirety for recommendation to the Council.

Coventry.—The gasworks are to be lighted electrically, the contract for the wiring and fitting being placed with Messrs. W. Coates and Son at £575.

Harrogate.—The Tender of the Edison and Swan United Electric Light Co. for supplying fittings for the new baths has been accepted. They sent in two tenders, viz.: No. 1, £297 17s.; No. 2 (alternative), £275 15s. 5d.

Metropolitan Asylums Board.—It being necessary to lay new electric light cables from the *Exmouth* training ship, the committee to whom the Metropolitan Asylums Board relegated the matter invited estimates from four firms for the supply of what was necessary. The estimates were as follows, and to avoid delay the committee accepted a tender immediately, without waiting for the sanction of the Local Government Board:

Callender's Cable Company	£197 0 0
Siemens Bros. and Co.	198 10 0
India Rubber, Gutta Percha and Telegraph Works Company	199 10 0
Johnson and Phillips	206 10 6

Spain.—Only one tender was submitted to the municipal authorities of Pozoblanco (Cordova) for the concession for the electric lighting of the town. This was submitted by Don Enrique Gosalvez, to whom the concession was granted.

NOTES.

The Electro-Harmonic Society.—The first concert of the 1896-97 season will take place on Friday evening next, with the "Dilettante" vocal quartett, Mr. Hopkins and his "Silver Bells," Mr. Churcher (recitations), Mr. George Schneider (humorous selections), and Mr. Alfred E. Izard, as solo pianist and accompanist. The vocal part of the programme, which can be seen in full in our business pages, is exceptionally good, and Messrs. James Brown, Edward Dalzell, Frederick Bevan and Robert Hilton, all old friends, are sure to secure the favour of the audience. A new song by Mr. Bevan is promised, although we are by no means enamoured of that gentleman's compositions. It may not perhaps be out of place to draw the attention of members to the hon. secretary's change of address from Woodvale, Honor Oak, to "Lytton," Mulgrave Road, Sutton, Surrey, where all communications should be sent.

The Soundness of Forgings.—In a series of able articles in *Industries and Iron*, on "The Conditions which cause Wrought-Iron to be Fibrous, and Steel low in Carbon to be Crystalline," by Mr. W. F. Durfee, the writer suggests that the position of an internal flaw in an ingot could be detected by joining the ingot in circuit with a battery and galvanometer and noting the deflection, then moving one of the wires along the ingot, thereby bringing a less length of the metal in circuit each time, and increasing the deflection by the consequent reduction of the circuit resistance. The writer then says:—"When the wire passes a point opposite the rupture, the law of increase of deflection will suddenly change, and a considerable increase of deflection of the galvanometer will be noted, thus indicating the presence of an internal breach of continuity in the ingot." We are perfectly certain Mr. Durfee could never have reasoned out his suggestion, otherwise he would have seen the absurdity of it. No such sudden change as he states could possibly take place, the slight reduction in the conductivity of the mass at the flaw would be infinitesimally small, and would not have the slightest perceptible effect on the galvanometer.

Electric Lighting of Small Towns.—The *American Electrician* calls attention editorially to that all-important matter of the use of the incandescent *versus* arc lamps for lighting villages and small towns. It is complained that usually the question is not gone into so thoroughly as it should be by those who have to decide upon the system to be employed. Our contemporary believes that arc lighting is often adopted because "a less glaring system of illumination might be considered to indicate a spirit too retiring on the part of the community employing it." Such may or may not be the case in the States, but we think that if incandescent electric street lighting were sufficiently satisfactory in regard to economical and steady working, and could be thoroughly relied upon, such a consideration would not weigh to any large extent with us in this country. The journal in question holds that in villages and residential thoroughfares in small cities the arc lamp is not in keeping with the surroundings, and also that it is "less efficient than incandescent lighting, both economically and optically." In a few of our English provincial towns and villages this is recognised, and the less important thoroughfares in Brighton and other places are lighted by means of incandescents, and, we believe, are giving satisfaction. The expense and unsuitability of arc lamps for lighting the side streets of the City of London appealed to the minds of the City Commissioners, and the matter has been under consideration for a great while, experiments being carried out to decide which is the best method to adopt. "For towns and smaller cities," adds our contemporary, "the ideal method of illumination is by the incandescent series system for residence streets and outlying districts, with arc lights for the main business streets, which latter lights may be employed only during business hours, circuits of incandescent lamps replacing them after the stores have been closed. As to the relative cost of arc and series incandescent lighting, let us assume that a 1,200 C.P. arc costs $80 per year, and that the annual cost of a 24 C.P. incandescent lamp is $14 per year. The lower hemispherical intensity of a 1,200 C.P. arc will not average over 300 C.P., which is equivalent to a cost of $6.40 for each 24 C.P. of light; but the average efficient illumination over the territory served will be less than with the rated candle-power equivalent in incandescent lamps, on account of the better distribution of the light from the latter. This comparison takes into consideration the waste of light in the immediate vicinity of an arc through its too great intensity, but does not consider the blinding effect on the human eye when subjected to such great variations of illumination as are incident to arc lighting when the lamps are widely spaced." The costs given by our contemporary for arc lights could not apply to this country, where the usual charge per lamp per annum is between £20 and £30.

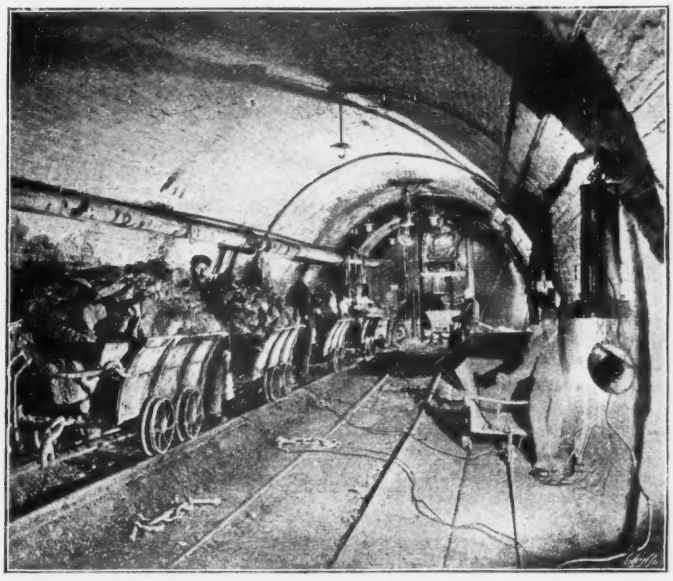
New Arc Lamps.—A new 100-hour constant potential arc lamp is described in the American papers, the principal feature being simple mechanism. Though a focus lamp, there is but one wheel in the mechanism, and the entire length is but 24 inches over all. The focusing feature involves a much smaller vacuum bulb, thereby securing a more perfect vacuum without depending so much on the joints at the inclosing device as in a fixed arc. This feature of a permanent centre of light will be appreciated by anyone having had experience with arc lamps. The upper and lower carbons are each held flexibly and guided through lava bushings, making it impossible for the carbons to slide past one another and reducing the trouble in trimming down to a minimum. The vacuum bulb is readily removed from the cross heads by simply lifting it up. The feed is accomplished by a simple positive device engaging the periphery of the one wheel in the mechanism, and is actuated by a single solenoid. The insulation used in the lamp is lava throughout. The lamp consumes 3½ amperes at 110 volts. Another American arc lamp—invented by Mr. Graves—also aims at simplicity of mechanism. It is intended to burn 125 hours without retrimming. To accomplish this, an inner globe is used. The carbon passes through a cover on the top of the globe, which gives a sufficiently tight joint for the purpose, and meets the lower carbon within the globe. In exterior work for trimming, the housing slides up and the globe slides down.

(*Continued on page* 374.)

ELECTRICITY DOWN A COAL MINE.

Mining engineers in this country are gradually beginning to appreciate the immense advantages offered by the electrical transmission of power over that of steam or compressed air, when the operations are carried on at a distance of, say, more than half a mile from the generating station. In America, the superiority of electrical apparatus in many phases of mining operations has been more fully recognised, as a glance through the columns of our trans-Atlantic contemporaries readily indicates. For some time past, however, experiments on a small scale have been carried out in different mines in the United Kingdom, and sufficient information has been obtained to warrant the introduction of much larger machinery than has hitherto been employed. Some years since Messrs. J. C. Howell erected an electrical hauling plant at the Abercanaid Colliery, Merthyr Tydvil, for the Hill's Plymouth Company, in South Wales; and this, with additions which constitute the latest development in the electrical system of power transmission, is capable of dealing with 1,000 tons of coal a day. It immediately replaced a large number of horses and their hauliers, and now that the workings are considerably extended, it is dealing with an amount of work which "All the King's horses and all the King's men" could not possibly tackle.

Underground Workings, Abercanaid Colliery, showing Roof Lighting.
(The loose cables are temporary arrangements for obtaining phtograph.)



Underground Workings, Abercanaid Colliery, showing Roof Lighting.
(The loose cables are temporary arrangements for obtaining photograph.)

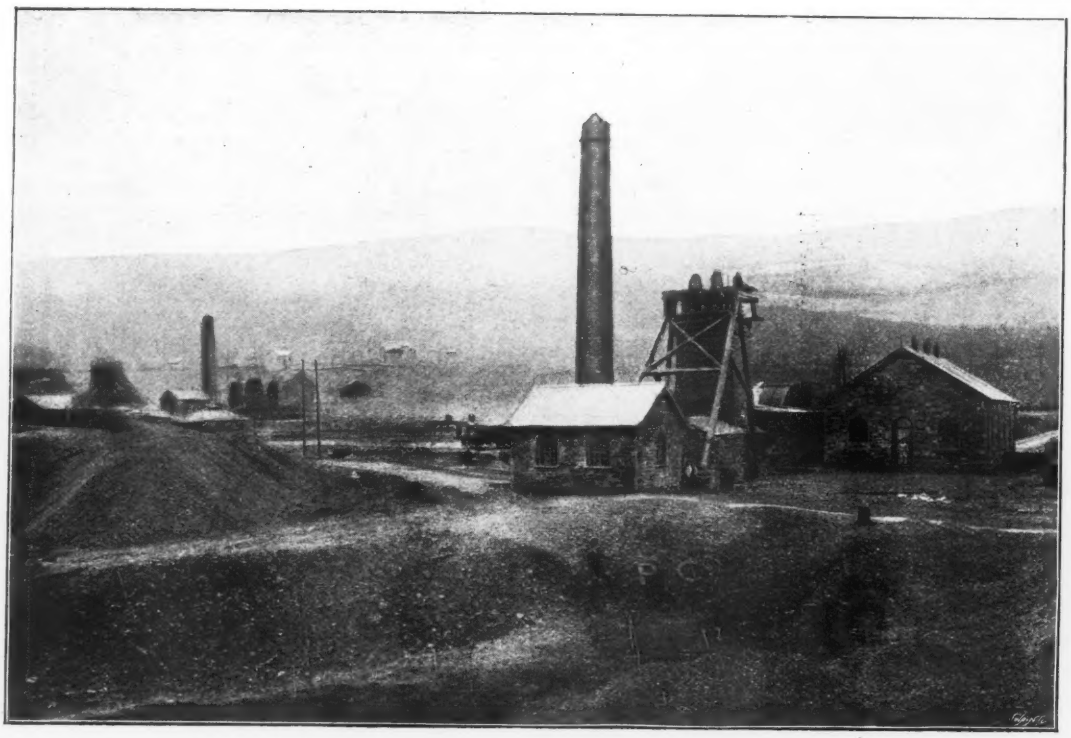
One miserably wet day, about a fortnight ago, we paid a visit to this mine, and, under the watchful care of Mr. Bates, the company's electrician, who did his best to conceal our identity by providing us with the necessary *matériel*, including the all-important safety lamp (not electric), to render us as much like a 4 feet 2 collier as possible—not altogether unsuccessfully, when one has to walk knees and nose together—we pensively contemplated the *modus operandi* of coal haulage for some considerable period.

The machinery consists of a generating plant at the top of the pit, which drives two main and tail rope haulage plants, and three pumps underground, connected by suitable cables carried down the shaft and along the roadway for some 1,200 yards. A small pump on the surface is also driven from the same generating source.

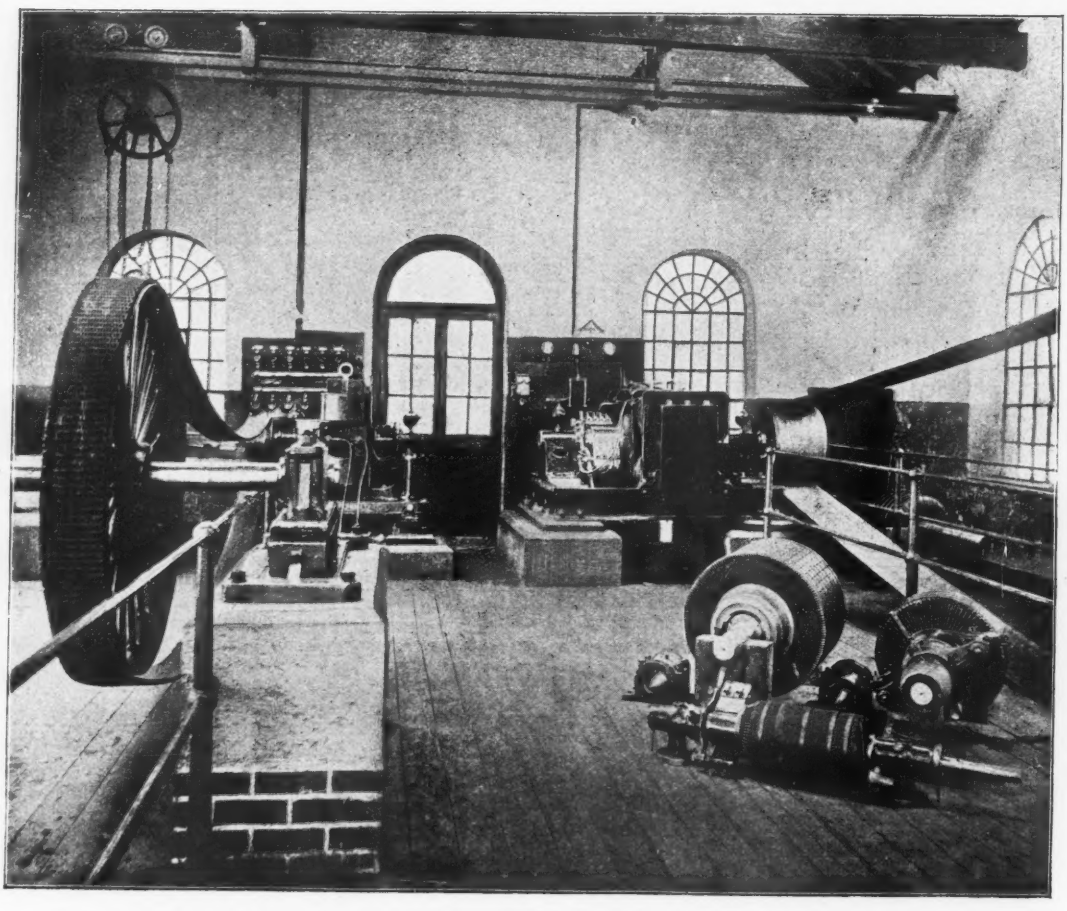
The generating plant includes a 40-H.P. compound condensing engine, with cylinders 13 inches and 21 inches diameter, and 24-inch stroke, working at 110 revolutions per minute. This engine drives direct by belt a specially constructed dynamo of the Crompton type. This machine is of the horizontal pattern, and is built on a wrought-iron girder bed-plate. It is compound wound, and is capable of giving 180 amperes at 500 volts pressure when running at 550 revolutions per minute.

The conducting cables, of which there are some 3,200 yards, are carried down attached to the side of the shaft, and from the shaft to the haulage engines are run along the roadway. This cable has been specially constructed to resist falls. It can stand a shearing strain of 10 tons per square inch, so that any danger arising from sparking owing to the rupture of the case is entirely avoided. The cable is made up of 37 strands of No. 14 B.W.G. high conductivity copper wire, highly insulated with vulcanised bitumen, double taped, and served with two layers of jute yarn compounded between each, and is protected by a double sheath of No. 8 B.W.G. steel wires, the first stranding being of 30 wires, and the second of 36 wires, laid up in a direction reverse to the first. The cable is of ample size to carry the current, 180 amperes, the current density being only 337 amperes per square inch, the resistance of the 3,200 yards of cable being ·3192 ohms, so that the loss of potential at full load is 51 volts, or 10 per cent.

In designing the combination of motors and hauling drums for a main and tail rope system, many points had to be carefully considered, and besides the necessity of making the plant very compact, it was necessary to design the motors so that any operation of starting, stopping or reversing, could be performed with the least possible trouble, and with great ease and swiftness; in fact, all these operations are carried out with the same facility as similar operations are carried out in machinery worked by steam or compressed air. The motor for No. 1 haulage is a series wound machine of the Crompton type, built to run at 800 revolutions per minute, and to work with 80 amperes current at 450 volts E.M.F., and at starting, when a higher current is required,

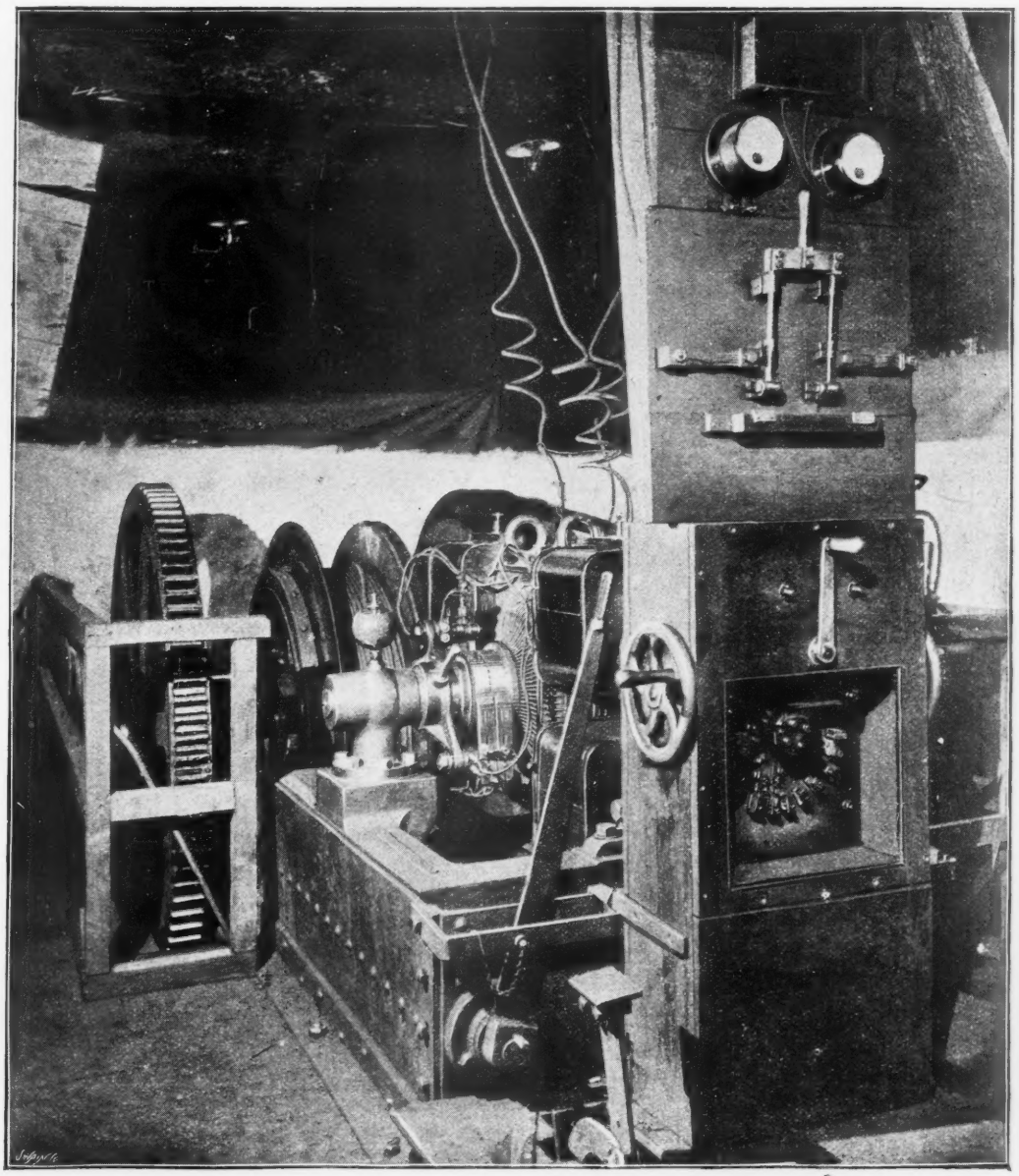


Abercanaid Colliery. The Generating Station is seen on the Right.



Generating Station, Engine End, at Abercanaid Colliery. Haulage Plant on Right, Lighting on Left.

it will take 160 amperes without harm. Indeed, all the machinery has been so designed as to be capable of bearing sudden and frequent strains far in excess of that which it is nominally called upon to withstand. The motor is placed horizontally at one end of a wrought-iron frame, which forms a bed for the drum and spur wheel. The drum shaft, which is of steel, is driven from a countershaft by means of spur gearing, and the motor drives the countershaft by means of six 1-inch cotton ropes. The haulage engine is fitted with two drums, 3 feet 6 inches diameter and 1 foot wide, fitted with clutches and foot brakes, and was built by the Uskside Engineering Company of Newport, Mon. This plant will haul coal from three different parts of the pit, and it is expected that eventually coal will have to be dealt with nearly a mile distant.



100 H.P. Main and Tail Rope Haulage Plant, Abercanaid Colliery.

This may be termed a 45 H.P. plant, but there is also a second of similar design but of larger power, viz., 100 H.P. Both are overrun, the first frequently being called upon to exert 100 H.P., and the second 150 H.P. and over. This was noticeable many times during our stay, both in the engine room on the surface and down the pit.

On emerging from that pit, literally a "gentleman of colour," and finding ourselves once again safe on "terra cotta," as Mrs. Malaprop has it, we were irresistibly reminded of the story of the two miners, who, after 12 months of hard work, resolved to take a day's trip to Blackpool and indulge in the luxury of a sea bath. After much diving and hard scrubbing they took a breather, and one, looking in astonishment at the completely altered appearance of his mate, exclaimed in a tone of wonderment, "Why Bill! I allus thowt thee wos'ta brunette!"

The general manager of the company, Mr. T. H. Bailey, to whom we wish to express our obligations, is stated to have said at the opening ceremony that his father had put down the first system of rope haulage in the Midland Counties 30 years ago, and the electrical system of haulage then inaugurated would enable the company to increase its output some 300 tons per day. A great difficulty in colliery enterprise was the labour cost, and the coal could not be got to the surface unless they had mechanical means to bring it up long distances. The system of rope haulage by compressed air was very costly, and they were thrown on their "beam ends" as it were, when Mr. Howell, of Llanelly, offered to supply this electrical plant. They found that the *capital required was only one-half that for compressed air, while the latter only gave 30 per cent. efficiency, and the electrical plant gave 65 per*

cent., which was a most important improvement. He added that he placed perfect reliance on Mr. Howell's system and working, more especially because Mr. Howell had erected their electric lighting arrangements at Abercanaid some six years ago, and they had *never had one hour's stoppage* since, which spoke well for the plant put in by him. The machinery must be well made and put up well to have satisfied them in this manner. He hoped and believed that the electrical haulage machinery started that day would prove the most economical machinery ever brought into South Wales. They found it impossible to go on with horses, and were glad they had put down an electrical plant, and they would have great pleasure in showing and explaining it to any gentlemen who were interested in such matters.

Mr. Bailey has since personally assured us that his experience of the last five years has considerably strengthened his belief in this mode of economically transmitting power to distant points, especially with regard to its application for haulage purposes.

The plant runs day and night, and a glance at the load curve during the journey of the heavily laden coal trams would appal a tramway engineer, and drive an electric lighting central station man to desperation. Fancy jumping from no load to more than 150 H.P., and this variation taking place every few seconds during the transit of the waggons, which go to and fro more than 200 times a day!

The regulation as to speed and reversing of the motors is accomplished by the Howell-Pownall patent switch, on which much time, money, and ingenuity were spent before it was perfected, and the control is such that the armatures of the motors, when revolving at 600 or 800 revolutions a minute, can be controlled to a quarter of a turn, and the manipulation of the switch is as easy, if not more so, than the controlling devices in a steam or compressed air hauling plant.

Indeed, it is not more difficult than playing a piano organ, to which it has been compared by the grimly humorous pitmen, and the whole plant is in charge of one of their number during each shift, no special training being called for on the part of the operator.

Electric haulage plant is of such a special nature, that to one who has been used only to surface engineering, such as exemplified in lighting and tramway work, the difficulties to be met and overcome, and the problems to be solved, say 200 yards beneath, would form a complete revelation, and the necessity of being *au fait* with all things which enter into a mining engineer's life becomes at once apparent. No wonder then that electric haulage is a speciality confined to a limited number of contractors, amongst the most successful of whom must be classed the London and Llanelly firm already mentioned, which has carried out a large number of mining contracts both for lighting as well as power.

ELECTRICAL FACTORIES AND THEIR MACHINERY.

No. III.

Some useful and interesting machines have been supplied to Messrs. Parkers, Limited, by Messrs. Hulse & Co., of Salford.

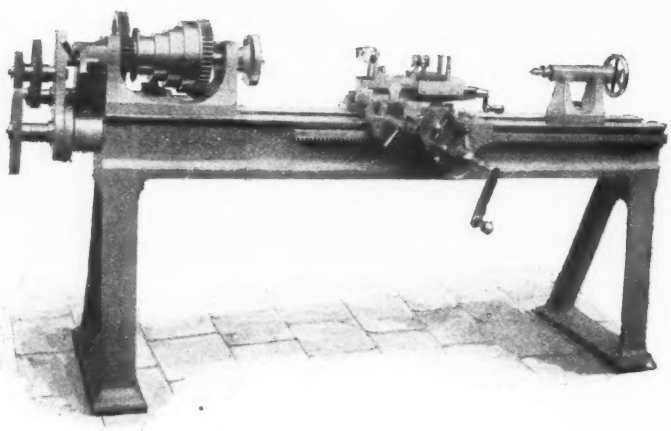


Fig. 2.

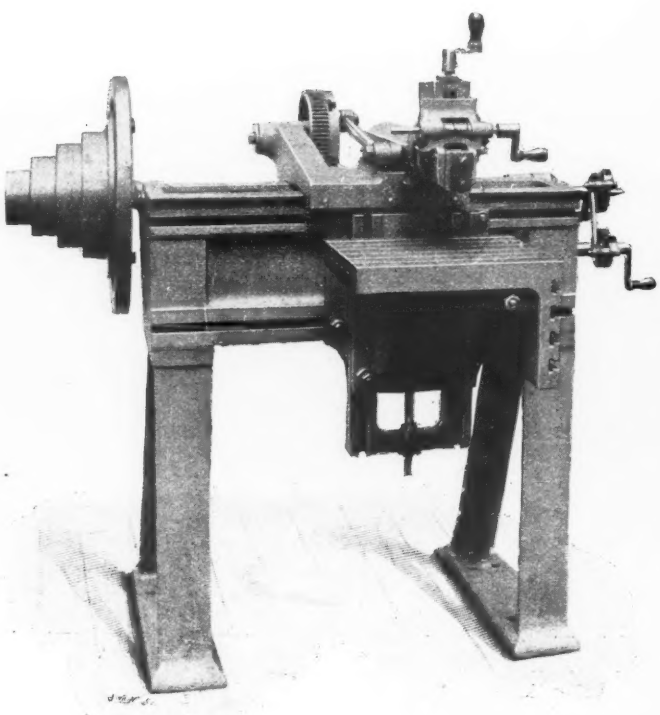


Fig. 3.

Fig. 1 shows a double side planing machine, capable of planing up to 20 feet long × 40 inches in width, with a main bed formed like the bed of a shaping machine, with vees to receive saddles on the top side, and tee-grooves to fix tables on the front.

Along the bed travel two sliding saddles, each carrying a fixed arm projecting over the tables. On each fixed arm are two tool boxes, adjustable along it, and each having vertical and swivelling adjustments. The arms face each other.

In front of the bed four tables are attached to the tee-grooves above referred to, each being adjustable vertically by handle at front end, acting through mitre wheels and vertical screw, and horizontally along the bed, by rack and pinion.

The sliding saddles are driven separately, each having its own driving pulleys at opposite ends of the bed with independent reversing and quick return motions — so that simultaneously a short article may be planed by one arm and a long article by the other — and at different levels, two tools operating on each article.

Fig. 2 is a 6-inch sliding, surfacing and screw-cutting lathe, with side shaft for sliding by rack and surfacing, driven by three-change gear to give a positive feed, and reversing gear to operate in either direction along the bed. The saddle carries a stay, and the rest is provided with a "quick withdraw motion" to facilitate screw cutting.

Fig. 3 shows a 6-inch stroke shaping machine. Bed 3 feet long, giving a horizontal movement of 1 foot 9 inches to the tool. It is provided with a table for holding the work with

the grooves on the top and one side, and with horizontal and vertical adjustments.

The driving is done by means of cone-pulley, with fly-wheel attached, and a variable stroke is given to the ram or tool slide by a disc. The tool holder is provided with segmental slide and worm wheel and index, for internal curves and angles, and a hollow mandril with arbor and cones with self-acting motion is added for external curved work.

There are few electrical factories where the necessity does not exist for wood working machinery, and those works which we have visited are well equipped with the most modern joinery tools. The joiners' shop at Messrs. Parkers

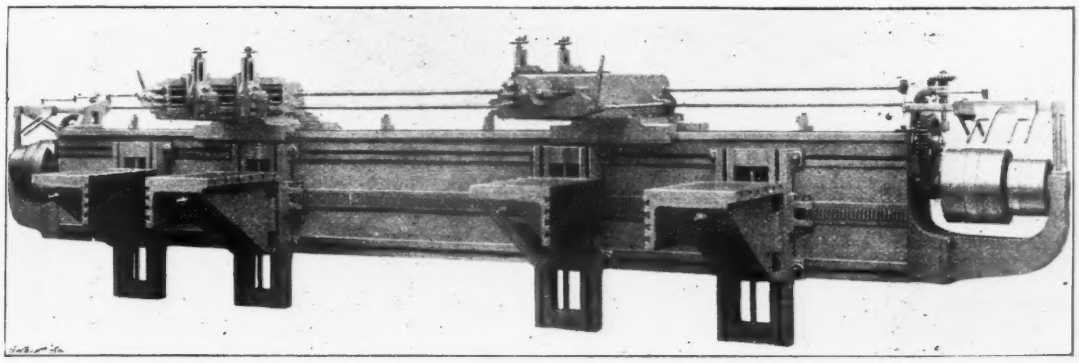


Fig. 1.

is distinctly interesting. One of the most prominent tools in this part of the works is a circular saw bench supplied by Messrs. Thomas Robinson and Son, Limited, Rochdale, and shown in fig. 4.

The framework of this bench is of one casting, and it is fitted with a rising and falling spindle.

The saw end of spindle is so arranged that the saw can be

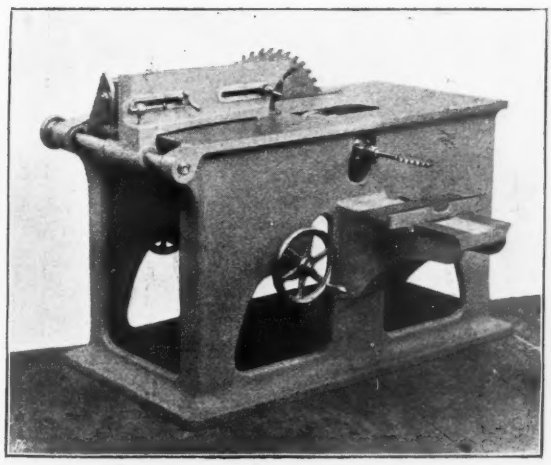


Fig. 4.

easily removed, and a cutter-block, with cutters, put in its place, to be used for tongueing and grooving, beading and rabbeting.

The bench can be also fitted with boring apparatus. The spindle end being bored to receive an auger, and a stand and sliding table provided for carrying the timber.

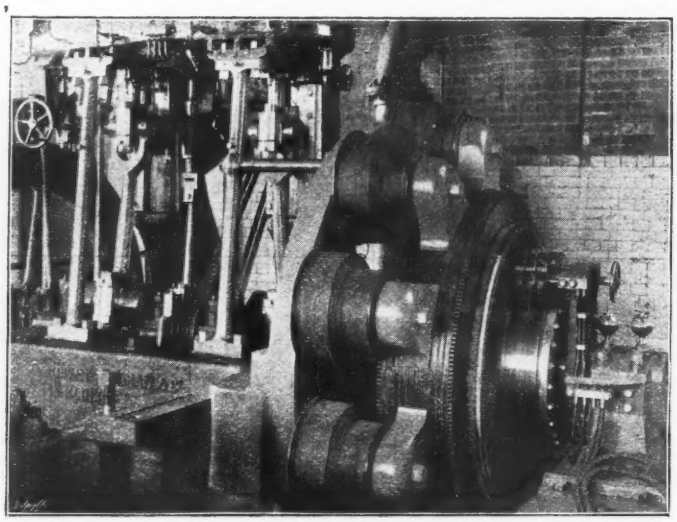
The parallel fence is made to cant at any angle, and can be easily removed for the purpose of cross-cutting.

The bench is capable of doing a variety of work in joinery and cabinet work.

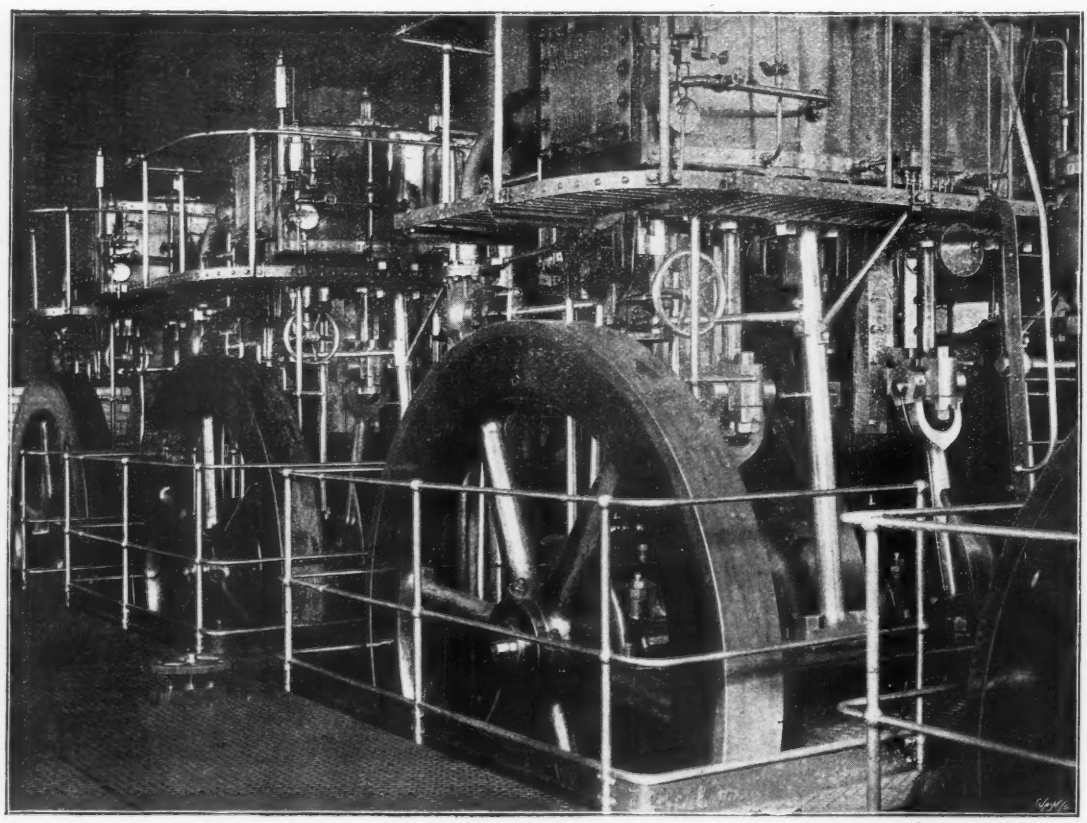
THE LIGHTING OF THE GREAT EASTERN RAILWAY COMPANY'S STATIONS.

The system of electric lighting which has been adopted by the Great Eastern Railway Company at their stations at Liverpool Street, Bishopsgate Street, and Bethnal Green Junction, is a low pressure three-wire, the extent of the distributing area being about 1½ miles. Although the demand for light on the Great Eastern Company's premises is in all probability as large as occurs in many towns, there is a very great difference in the conditions that exist. It is impossible to tell to a nicety what the demand is likely to be on the station premises, but it is not difficult to know at what hour the heavy load will come on, and at what hour it will go off. Another important consideration is that the heavy load lasts for a considerable time, the result being a load curve which is much more favourable for low costs than the average public lighting station. Leaving this phase of the subject, however, for the moment, we will give a few details of the plant.

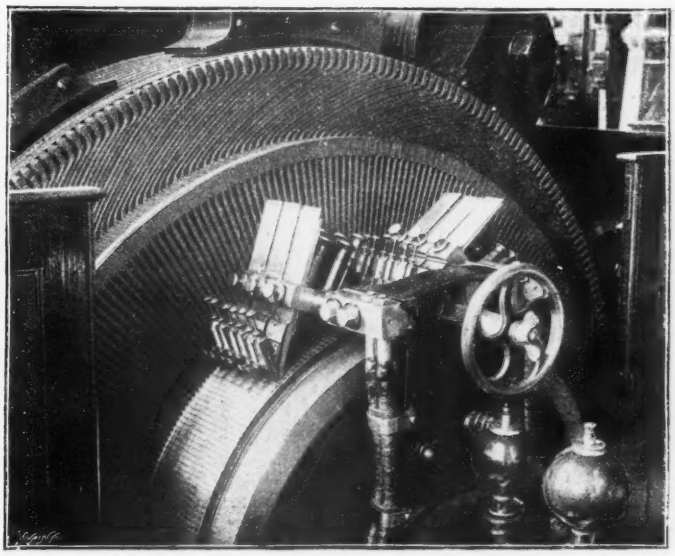
Beginning with the steam raising plant, it is interesting to note five marine boilers are employed, the type being Messrs. Paxman's "Economic," each boiler having 998 square feet of heating surface, and working at a pressure of 120 lbs. There are several vertical compound non-condensing engines of the Windsor type, supplied by Messrs. Davey Paxman and Co., four being of 200 H.P., and three being of 100 H.P. each. The larger engines run at 120 revolutions per minute, while the smaller ones run at 150 revolutions. There are one or two novel features about the electrical generating plant which are distinctly interesting. The plant is in all cases direct-coupled, and as the larger engines run at a low speed, it has been necessary to adopt rather unusual methods in constructing the larger dynamos. The 200 H.P. sets, therefore, have armatures 8 feet in diameter, and have 10 poles; the armatures of the main dynamos being in all cases of the drum type, and the fields being shunt wound. As we have already suggested, there are four machines with 10 poles, and, in addition, there are three four-pole and two two-pole. The output of the large machines is 500 amperes at 240 volts, while the three smaller sets have an output of 250 amperes at the same voltage, and the two smallest sets an output of 100 amperes at 240 volts. In addition to this plant is a set comprising two secondary dynamos driven direct by a motor, which is supplied with current from the main omnibus bars. The whole of the generating machinery has been supplied by Messrs. Crompton and Co. Working in conjunction with the generating plant is a set of 126 accumulators of the Crompton-Howell type. This battery has a capacity of 1,000 ampere hours, and can work for some hours at a discharge of 140 amperes. The function of this battery is to help the machinery at the time of maximum load, as well as to supply the very early day load. It also permits of the plant being entirely shut down on Sundays. Naturally arc lighting forms one of the chief features of the Great Eastern



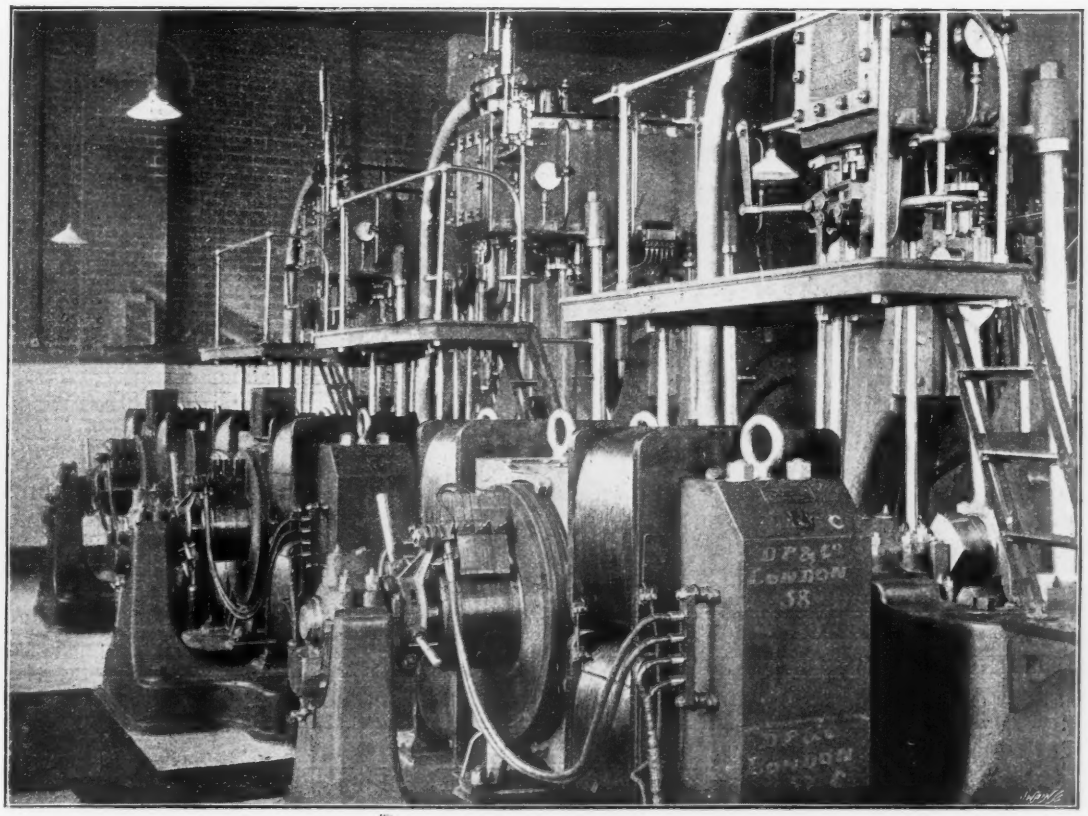
Great Eastern Railway Company. Side View of 10-Pole Machine.



Great Eastern Railway Company. General View of Engines.



Great Eastern Railway Company. One of the 8 feet Armatures.



Great Eastern Railway Company. General View of 4-Pole Machines.

system. There are 230 Crompton-Pochin differential arc lamps, each of a nominal C.P. of 2,000. The majority are of 10 amperes, though there are a few of 15 and 7 ampere type. They are mounted on iron lattice poles, and are mostly enclosed in opaline globes. The height of the arc from the ground varies from 20 to 55 feet. Although the arc lighting forms a considerable portion of the system, there are in addition some 3,386 incandescent lamps of varying C.P., the largest being 50 C.P., and the smallest 8 C.P. The distribution is carried out on the 3-wire system, the arc lamps being arranged four in series across the two outers. The average annual consumption of current is 869,336 kilowatt-hours, and the cost per kilowatt-hour, including interest, repairs, amortization, light, carbon, &c., is as low as 2·38d. per unit, the cost per ton of fuel delivered at the power-house being 12s. 8d.

THE OERLIKON COMPANY AT THE GENEVA EXHIBITION.

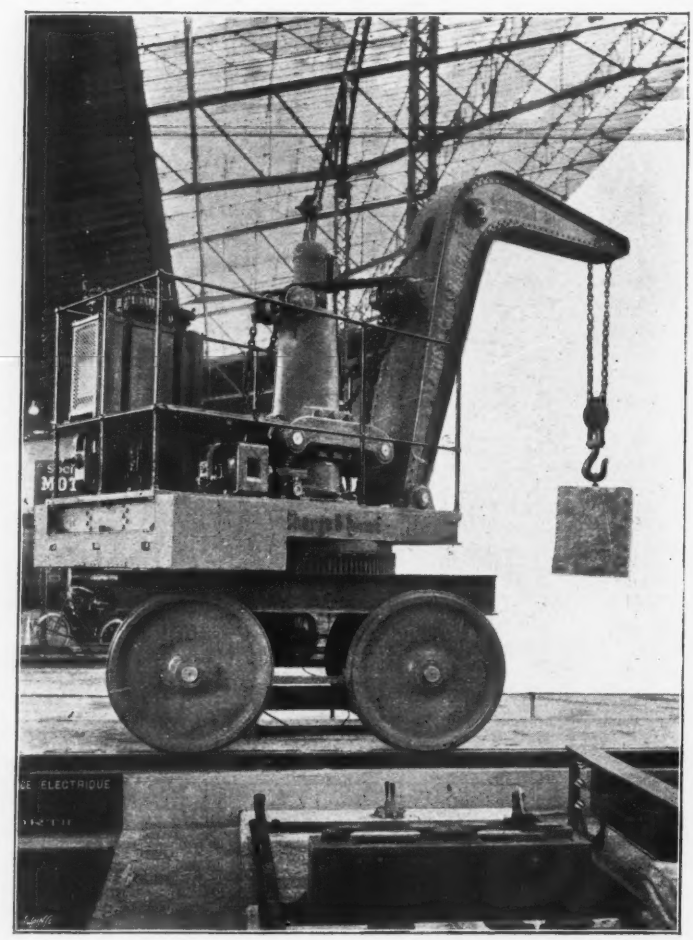
It has not been possible adequately to represent at the exhibition all the specialities of the Oerlikon Works. One very important branch—*electric traction*—is absent, but this does not suggest that the Oerlikon Works do not enter into this branch of electrical work, for they are now constructing the Nishni-Novgorod tramway, the St. Gall tramway, the Altstätten-Berneck electric railway, the Neuchâtel-St. Blaise tramway, the Zurich-Oerlikon-Seebach tramway, the traction at the copper mines of the Boléo Company, and at the coal mines of the Mouths of the Rhone, the two last being worked by triphased currents.

To demonstrate as far as possible the progress realised in the industrial application of electricity, the construction of dynamos of the various recognised systems is represented only by a few characteristic types, in order that the principal applications of electro-motors may be shown in a series of varied examples.

The continuous current dynamos for lighting which are exhibited are of low power. They give an idea of the types and modes of construction adopted by the firm. For high powers, the continuous current machines are generally made like fly-wheels in combination with steam engines. This type is not represented at the exhibition. Amongst others, two dynamos of this kind of 800 H.P., running at 105 revolutions per minute, are in course of execution at the works, for the "Sociedad Madrilena," Madrid.

The dynamo of 710 H.P., for the manufacture of aluminium, is of a type made specially for *electrolysis*, which requires a *régime* very different from that of ordinary electrical work, since it necessitates a continuous service prolonged for several months at full load. Altogether the dynamos made for electrolysis up to the present represent about 16,000 H.P. Four machines, of 800 H.P. each, at 240 revolutions a minute, of the horizontal axle type, are now in course of execution. Five others, of 850 H.P., at 55 revolutions, with vertical axle, intended for the new installations at Rheinfelden, of the Aluminium Industrie Actiengesellschaft at Neuhausen, have just been ordered. The *monophased alternator*—which we illustrate—of 230 H.P., at 2,400 volts, exhibited in the division allotted to Messrs. Escher, Wyss & Co., and also the 100 H.P. *triphased alternator*, at 200 volts, exhibited by the firm, are of the Oerlikon type, with fixed winding. Apart from the good electrical qualities that distinguish these generators, the absolute absence of winding on their revolving part is a very important consideration. In the two models exhibited are shown the two modes of winding the armatures, either by bobbins made to pattern beforehand, or winding by bars, generally applied.

From the summer of 1895, at which time the Oerlikon Works sent out the first alternators of the type with fixed winding up to the present day, they have installed machines of this type representing a total power of about 4,500 H.P., and 50 machines representing a total power of about 25,000 H.P., are now in course of construction. Amongst these machines the following are worthy of mention :—



Travelling Crane Driven by Continuous Current Motors.

1 fly-wheel alternator of 800 H.P. at 100 revolutions, for the Zurich central station ; 8 fly-wheel alternators of 1,000 H.P. at 107 revolutions, for the central stations of Genoa, Berlin and Oberspree ; five alternators of 850 H.P. at 55 revolutions, with vertical axle, ordered by the "Aktiengesellschaft Kraftübertragungswerke Rheinfelden."

These machines for *Rheinfelden* have, on account of their very reduced speed, remarkable dimensions (weight 110 tons). The tri-phased alternator, of 20 H.P. at 110 volts, coupled to an Escher, Wyss and Co. turbine, is of a different type. Its construction is economical, and is well adapted for small installations.

Side by side with the alternators are shown transformers and motors for monophased and triphased currents, for high and low tension, with and without starting resistances and regulation of speed in the armature.

Although the Oerlikon Works adopt in their alternate current installations only monophased and triphased currents, they make to order biphased motors for existing installations. In the Exhibition, even, there are several at work among the various exhibits.

Lifting apparatus is represented by a travelling pivoted

crane of 5 tons, worked by continuous current motors, constructed specially for loading and unloading the waggons at the works. This crane is shown in one of our illustrations.

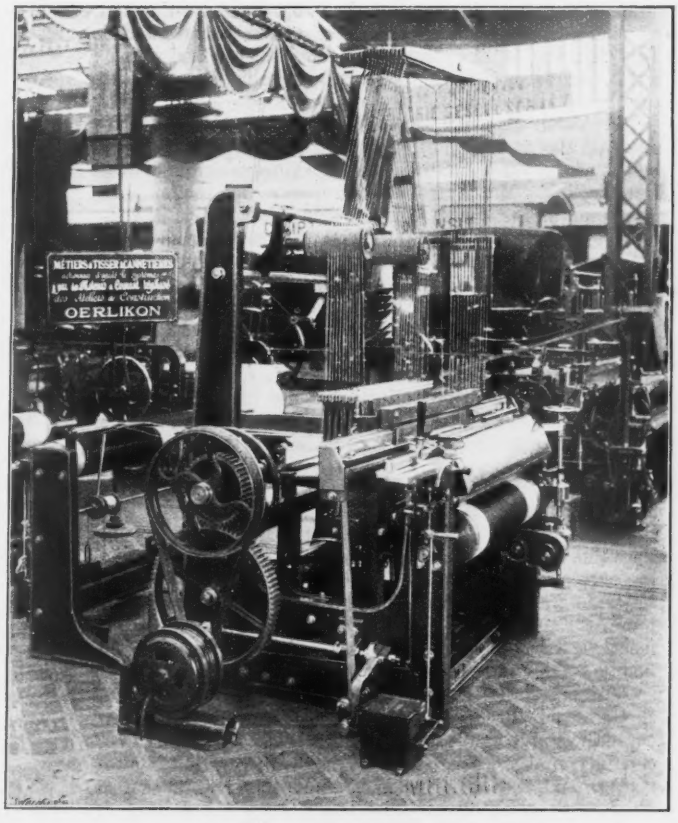
In connection with lifting apparatus, we must mention another item of current manufacture which has not been able to be exhibited, the *rolling bridge worked by electricity*, which is gradually taking the place of bridges worked by cables.

The crane exhibited, and also the bridges above mentioned, are constructed both for continuous and triphased currents. In both cases the different movements are made by independent motors varying in size according to the force required, so that all intermediate apparatus such as gearing, friction cones, couplings, &c., are dispensed with. Other raising apparatus constantly being constructed are windlasses for inclined planes, and wells and lifts, also worked by electricity.

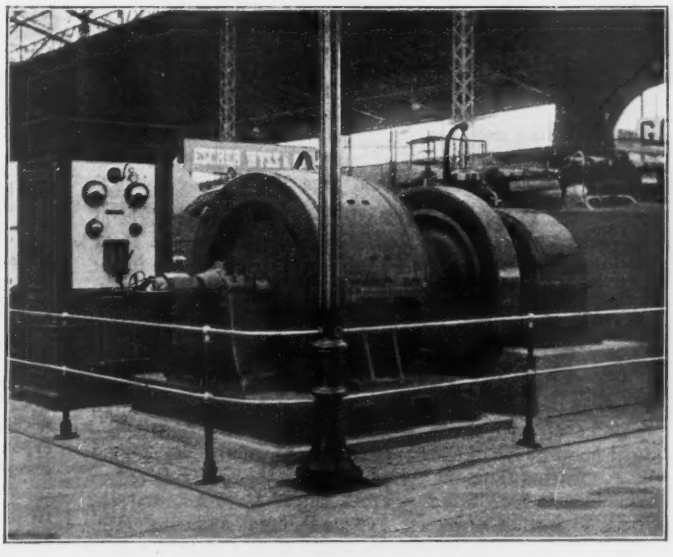
The number of rolling bridges alone constructed amounts to about 120, with a total load of about 1,200 tons, the most powerful being 65 tons. Twenty bridges with a total load of 250 tons are now in course of construction. The third illustration gives an idea of three-phase motors used for driving looms.

We are indebted to Mr. Hirst of the General Electric Co., Limited, for the photographs which are illustrated in this article. The General Electric Company, we may mention, work in this country under a license from the Oerlikon Company.

(*To be continued.*)



Three-Phase Motor Driving Loom.



Monophased Alternator of 230 H.P.

TECHNICAL EDUCATION IN ENGLAND AND GERMANY.

The letter of Prof. Ostwald on technical education in England and Germany, which we lately commented upon, has given rise to an interesting discussion in the *Times*. The correspondents of the *Times* are pretty generally agreed that scientific and technical education are better done in Germany, but they are by no means agreed as to the causes of this. Neither are they quite sure that our deficiency in technical education is the cause of our recent industrial relapse.

Prof. Tilden considers that chemical and physical education are neglected at Oxford and Cambridge. The teachers, however, at a number of the colleges in the provinces, are as competent as German professors, but they have not the same social position, and have to add to their incomes by acting as scientific experts and such like, instead of directing the work in their laboratories. In Germany, the University professor is a great man, well paid, received at court and honoured by all classes of the community; and this because he is an eminent man of science. In England a few chairs are pretty well paid, but the majority very badly; and the public regards professors generally as unpractical dealers in useless wares. The student of physics and chemistry are more thoroughly taught in the earlier stages of his career in the better English colleges than in the German universities. Brewers appear to be the only manufacturers in this country who have employed original researchers; three scientists employed by leading brewers were F.R.S's. We have only solitary manufacturers, like Sir Lothian Bell, who have themselves gone in for original research. Prof. Tilden condemns the technical education of workmen; the money should rather be concentrated in provincial colleges. He considers, however, that the whole of Germany's success is not due to superior science; her university system is partly superior to ours, but the large number of students he considers to be due, to a great extent, to the desire to escape from military service.

Mr. Samuelson, who was a member of the Technical Commission of 1882, has a very poor opinion of our polytechnics as technical schools. They supply, he says, amusement and humanising influences to the working man, but have little influence on industrial progress. He found the artisans in France and Germany were in most cases uneducated labourers; but in the great colour works in Germany he found Ph. D.'s directing every department. To teach physics and chemistry to artisans, he considers to be on a par with teaching "Tommy Atkins" strategy and tactics. Mr. Samuelson, however, believes as little in giving a scientific training to the manufacturer; for him he recommends the liberal education which brings the sound judgment which is denied to the mere scientist.

Dr. Thorpe, like Prof. Tilden, blames Oxford and Cambridge for not leading the schools in scientific studies. The provincial colleges at Manchester, Liverpool, Leeds, and Birmingham, he considers, devote their best energies to the teaching of science, but they are crippled for want of funds, and ought to have more generous assistance from the State. Thorpe condemns the examination system as an injurious restriction on the development of scientific teaching.

Mr. Friswell considers that the blame lies with the English manufacturers, who do not value science as they ought to do. The Germans, on the other hand, value science at its true worth, and hence the scientific expert finds his place, and in turn benefits the community.

Mr. Marsh stands up for Oxford and Cambridge. He says that the provincial colleges have now been doing their best for some years, and they have failed to save our industries from decline. Mr. Watson Smith thinks that the middle-class and higher school education, in this country, is deficient, especially in mathematics, and that our students spend too much time in outdoor sports.

The opinions of all these authorities show how little agreement there is on this important question of technical education and its bearing on industry. It appears to be undecided whether the fault lies with the manufacturers who will not make use of the scientific and technical expert, or with the educational institutions that are incapable of producing him. Again, it is a *venata questio* whether the blame which may lie on the schools is to be laid on the preparatory schools, the colleges, or the universities. The value of a technical expert must, of course, depend greatly on the nature of the manufacture. Chemical manufacturers, and also brewers, appear to have already recognised, to some extent, the value of the scientific expert; but in electrical engineering, which one would think demands even a more profound scientific knowledge, there appears to be little demand for him in England. At least, if we compare the advertisements in German and English electrical journals, we usually find that the German engineer seeking for a sphere for his activities carefully specifies the course of study he has gone through and the examinations he has passed; the English engineer, on the contrary, keeps his school and college career carefully in the background, or omits to mention it altogether. We fear Prof. Tilden is right when he says that in England the scientific professor is generally looked upon as "an unpractical dealer in useless wares," and we have in another place endeavoured to deal briefly, but practically, with this subject under the heading "Some Reflections."

NOTES.

(*Continued from page* 364.)

Electric Power Transmission.—The General Electric Company, of New York, recently gave out information from its mining and power department, showing the growth in the use of electric power, and also its economy and efficiency. The figures which represent horse-power refer to electric power apparatus only :—

	1892.	1893.	1894.	1895.
H.P.	13,719	18,762	42,379	46,727

In 1896, the missionary work of the past four years began to come to rapid fruition. From January 1st to July 31st, the total horse-power of the apparatus amounted to over 48,000 H.P. During the same period, in 1895, the aggregate orders amounted to 25,737 H.P. From August 1st to August 18th, the total amount of power apparatus ordered during 1896 was increased to the respectable figure of 62,164 H.P.

Good Work!—An exchange records a good instance of hard work performed by an electric railway motor. A Madison City motor car, equipped with a G.E. 800-motor, was considerably overloaded. Connected to it were four trailer cars, containing not less than 500 persons, and a speed of seven miles an hour was maintained, the motor car and train running up the heaviest gradients without difficulty.

Railway Conventions in the States.—The Street Railway Convention to be held next month at St. Louis is to be a very big affair. It will open on October 20th, and close on 23rd. One large section of the great Convention Hall will be devoted to the meetings, another section being set apart for exhibits. In regard to the latter branch of the convention, it appears that a large number of manufacturers have applied for space in extent varying from 2,000 square feet to 100 square feet, and here will be shown cars, tracks, motors, and all the various apparatus used in electric traction works. The list of papers include one by Mr. B. Willard on "Modern Overhead Electric Construction," and one by Mr. Richard McCulloch on "The Modern Power-House." Mr. M. K. Bowen will refer to "Track and Track Joints: Construction, Maintenance, and Bonding," and Mr. J. N. Akaman to "Trucks." During the several days of the Convention, delegates will have the free use of all the street cars in St. Louis. When we read of these great conventions being held across the water, and think how vast is the extent of the electric tramway business there, we cannot help wondering how long we shall have to wait for this sort of thing in Old England. Electric street railway conventions in London are at present a long way off, we imagine, seeing that the chief city of the world cannot yet boast a mile of electric street tramways.

Another gathering of the same character is to be held in Binghamton, on September 8th. It is the annual convention of the Street Railway Association of the State of New York, and in order to crowd as much work into the smallest possible period of time, a special feature of the programme is the reading of short papers upon subjects of everyday importance. None of these papers will be allowed longer than 12 minutes for discussion. They will be taken as read.

American Association for the Advancement of Science.—American science honours its representatives by an election to the National Academy of Sciences or by an election to the presidency of the American Association for the Advancement of Science. This year the last-named organisation is fortunate in having as its presiding officer a scientist who (says Mr. Marcus Benjamin in the *Scientific American*) is also a member of the National Academy, for Prof. Edward Drinker Cope, who ranks among the foremost of American paleontologists, presides over its Buffalo meeting. Prof. Cope studied comparative anatomy in the Academy of Sciences, in Philadelphia, and in 1859 he joined the group of young naturalists who were associated together in the Smithsonian Institution under Prof. Baird. Their names are best recalled by the following stanza, improvised by one of their number, after a hotly contested argument on some disputed point in natural history :—

Into this well of learning dip with spoon of Wood or Horn,
For students Meek and holy silver spoons should treat with scorn.

If Gabb should have the gift of Gill
(As Gill has gift of Gabb),
'Twould show a want of judgment still
To try to Cope with Meek.

A Cable Attacked by Termites.—M. E. L. Bouvier has recently examined, under the instructions of the French Telegraph Administration, a piece of cable from Haïphong, which had been attacked by some organism. The cable, it appears, was laid as recently as July, 1894, and in the early part of 1895 showed signs of becoming defective. In 1896, a month or two ago, it became necessary to renew the cable. The latter was of the ordinary type with three conductors, the outer serving being two layers of tanned cotton tape, and the whole enclosed for most of its length in a lead pipe. The cable was embedded in cement along its length. No previous case of a cable being damaged in the locality had been known, although much of the cable in use was unprotected by sheathing, but the particular cable in question was in a different kind of soil to that in which the other cables were placed, the soil being constantly wet and of a light description. The termites left the lead untouched, but had scored channels in the gutta-percha, having entered apparently at the ends of the lead pipe, or at some defect in the latter. M. Bouvier recommends that any new cables of the same type as those injured should have the hemp sheathing saturated in sulphate of copper.

The Dumoulin Copper-Depositing Process.—A process of some possible potential importance is being experimented with in England for the purpose of depositing copper electrolytically, in the form of sheets and tubes, direct from the matter or precipitate. It will be remembered, says the New York *Engineering and Mining Journal*, that the Elmore and other similar processes have proved failures, owing to the sheets and tubes thus made lacking strength and homogeneity. The present process is the invention of M. Emilien Dumoulin, of Paris, or at least he is the patentee, the actual inventor being a metallurgist and chemist in his employ. The essence of the invention is the special method for rendering the arrangement of the deposited molecules perfectly homogeneous, and thus obtaining uniform strength in the tube as it is formed on the revolving mandrel. In the Elmore process it was endeavoured to attain this end by continually pressing on the deposit with an agate edge; but the results did not fulfil expectations, for the agate edge not only did not render the deposit homogeneous, but also did not make the succeeding layers adhere to one another. In the Dumoulin process, a body impregnated with greasy matter is placed in contact with the mandrel, so that if any irregularities occur in the deposition of the metal the projecting portions press into the body and squeeze out and become covered with grease. As the grease is a non-conductor, further deposition cannot take place on the prominences, but is confined to the hollows. When the metallic surface becomes level again the grease is automatically rubbed off or taken up again by the body. In this way irregularities of deposit are prevented, and so little pressure is put on the surface that lamination does not occur. The patent for this process has been acquired by an English company, organised by Mr. R. M. Moir, who was once connected with the Rio Tinto Company. Mr. Moir has interested the Rio Tinto people, and Messrs. Matheson & Co., and they and Mr. McKechnie, a Widnes smelter, have conducted severe tests of the process. The tests for strength made by Kirkaldy show a breaking stress varying from 45,000 lbs. to 52,000 lbs. per square inch, with an elongation from 10 to 21 per cent., very high figures. The specific gravity of the copper is 8·94, and the electric resistance is 1,580 to 1,590.

New American Electrical Carriage.—Our friends of the New York electrical Press last month went for a ride in a new electric brake, which has been constructed by the American Electric Vehicle Company, of Chicago. This brake is to be sent all over the States by the owners, stops being made in the principal towns, and the carriage driven through the streets. A lavishly furnished Pullman car will accommodate by day and night those who take charge of the brake. In the middle of the car is a place for the brake when travelling by rail from town to town. The brake is equipped with two 2-horse-power single reduction motors which can be worked up to about double their nominal capacity when necessary. Instead of the sprocket and chain gear which has been so generally used on horseless carriages, the two motors are geared direct to the rear wheels of the vehicle by two small raw-hide pinions on the motor shafts, meshing into large brass pinions attached to the axle inside the wheels. Attached to each of the motors are also two geared wheels for the purpose of changing the speed of the motor shaft when necessary, this unique piece of mechanism being regulated from the driver's seat. The carriage is also equipped with controller, brake and steering apparatus, and for night runs two incandescent lamps are used, which are enclosed in handsome lamp-holders of the regular type used in carriages. The carriage is very light in appearance, contains two seats capable of holding six persons, and will be able to run up to a speed of 14 miles an hour. The motors and controllers are of a special pattern made by the American Electric Vehicle Company, the storage batteries being of the well-known make of the Syracuse Electric Battery Company Syracuse, N.Y.

Burglary.—The offices of the Douglas Southern Electric Tramway Company, which are situated at a lonely place and overlooking the sea at Douglas, I.O.M., were broken into last Sunday morning, and the safe, containing a considerable amount in gold and cheques, forced and ransacked. The thieves afterwards took away the safe, weighing 3 cwt., and threw it into the sea.

The Heat Conducting Power of Metals.—After a thorough investigation of this subject, Herr W. Beglinger has arrived at the following conclusions:—The results show that the heat conducting power of the different kinds of iron is altogether different. It is, therefore, of the greatest importance to know the coefficient of the inner heat conducting power. Steel and wrought-iron show a more uniform behaviour in this matter than cast iron. It is not confirmed that hardening reduces the conducting power of steel by almost one-half, though it may be conceded that hardening will reduce it slightly. The difference in working, by forging or rolling, showed only in one case, with wrought-iron, considerable differences for the conducting power. Casting seems to cause far more irregularities. Wrought-iron showed generally better conducting power than did steel. Herren L. Holborn and W. Wien have compiled a table, which we reproduce from the *Scientific American*, showing the heat-conducting power of the different values. The average value for the different kinds of iron and steel is given. The factor, R, indicates that through a plate of 1 centimetre thickness, at a difference of temperature of 1°, for 1 square centimetre each, a quantity of heat passes which will increase the temperature of R gramme of water by 1°:—

Copper	R = 0·918
Iron	R = 0·156
Steel	R = 0·062 to 0·111
Zinc	R = 0·292
Tin	R = 0·150
Lead	R = 0·079

A Note for Busy Men.—Lord Kelvin, according to a monthly magazine, has an extraordinary power of becoming dead to what is going on around him, and centring his thoughts upon deep scientific matters. He has been observed, when on a visit to some country house, in a crowded drawing room, with all the jabber of society gossip going on in full flood, sitting with his note book, and filling page after page with intricate calculations, seeking the solution of some problem which awaited investigation. It is said that he is never without one of these pocket tablets. This gift of lifting oneself out of one's surroundings, and soaring above common mundane concerns seems to be a peculiar gift with which many great minds are blessed. But it seems to be very exceptional in Lord Kelvin's case, if what the writer says in the magazine in question is correct, for we are told that he has passed through a gale sitting in his cabin at work without being conscious of the storm. He must be an exceptionally good sailor! The method of carrying a pocket note-book has proved invaluable to men of various callings. We believe most central station and other electrical engineers make a practice of jotting down points in this way. A good hint may strike the mind at any time during the day when running or laying down plant, or superintending the laying of cables, or even when fitting up premises. When these ideas come the wisest course is to "take a note of" them, otherwise they may be forgotten, only to be remembered again when some one else has discovered and made use of them. Such notes, properly registered and considered at leisure, might lead to the unfolding of a multitude of new ideas, and ultimately redound to the benefit of all.

Science Classes.—At the City of London College, Moorfields, classes are to be held during the session commencing October 1st in magnetism and electricity, mathematics, chemistry and other science subjects. For prospectus, apply to Mr. David Savage, the secretary.

Autocars.—At the meeting of the Great Horseless Carriage Company last Friday, the chairman, the Earl of Winchelsea and Nottingham, said the company was making progress with the application of electricity to horseless carriages, and had confidence that it would be a very great success. The choice of agencies was between electricity, steam and oil. For the present, at least, he thought the use of electricity would be found advantageous to those towns which could obtain a supply of it at a moderate cost. Of course, in London, the electricity supply companies were willing to supply electricity cheaper in the daytime than at night. With regard to oil, petroleum he thought would be more used in rural districts.

The B.A. Meeting.—After an interval of a quarter of a century, the British Association has gone again to Liverpool, where its sixty-sixth annual meeting commenced on Wednesday evening. This is the fourth time that Liverpool has been the town selected for these assemblies, and there was a crowded attendance in the Philharmonic Hall. Sir Douglas Galton, the retiring president, after a brief speech, vacated the position for his successor, Sir Joseph Lister, whose opening remarks were confined to X rays, but he advanced nothing which is not quite familiar to our readers, and the remainder of his address was directed entirely to matters connected with the profession in which he forms so conspicuous a figure. Invitations have been received as to the meeting of 1898 from Glasgow and Bristol, and in response to a communication from Paris to the effect that the French Association for the Advancement of Science would meet in 1899 at Boulogne, it was agreed favourably to consider an invitation received from Dover to hold the British Association meeting for that year in that town, in order that the members of the two Associations might have an opportunity of exchanging visits from the opposite coasts. With regard to the Toronto meeting of the British Association next year, it was agreed that the officers of the United States Association should be received on that occasion as honorary members, on the same terms as old annual members of the British Association.

Lock Armour for Electric Light Cables.—Just as we go to press, the following letter has reached us from Callender's Cable and Construction Company, Limited :—

Our attention has been called to a circular issued by Messrs. W. T. Glover & Co., descriptive of "Glover's Patent High Conductivity Lock Armour," which is claimed by that firm to be their invention, and to the article in your last week's issue dealing with this cable. We give you notice that this is an infringement of the lock coil patents, which were issued to Messrs. Latch and Batchelor in 1884, which patents are the property of Messrs. George Elliot & Co., the well-known colliery owners and wire rope makers of Westminster, Cardiff, and Newcastle-on-Tyne, who have granted us the exclusive right to use this invention in connection with electric cable work in this country. Very large quantities of this lock cable have been made during the past 10 years for haulage and other purposes by Messrs. Elliot, and its advantages are fully appreciated by mining engineers. We have already manufactured many miles of cable under our license with lock coil armour, in some cases the steel segments serving merely as a mechanical protection, in others the armouring being used as the return conductor, and we have no intention to allow our rights under these patents to be infringed. Our solicitors are taking the necessary steps for our protection, and we desire to give public notice that we shall take proceedings against any firm manufacturing, or against any person, company, or corporation using cables, any part of which is formed of segments which, when put together, interlock so as to form a complete locked ring or shield on the cable, or otherwise infringing the patents in question. We shall be obliged by your giving to this letter equal publicity to that given to the notice of Messrs. Glover in your issue of last week.

T. O. Callender, *Managing Director.*

The Electric Lighting of the Great Wheel.—The Great Wheel at the Earl's Court Exhibition is now put to a novel use for advertising purposes. The name of a weekly paper in letters 30 feet high has been inscribed by means of electric lamps between the outer and inner circles, the light being given by 260 incandescent lights of about 30 C.P. The letters are in gas piping, the electric wires being inside, and issuing through holes to feed the lamps. It is claimed that this advertisement will be visible five or six miles away.

Gas.—A gas explosion at Newbiggin-by-the-Sea resulted in the death of a lady from burning, and completely wrecked some shop premises.

Some premises in Oxford Road, Reading, used as a Telegraph School, were wrecked last week through an explosion consequent upon a gas leakage. A number of pupils and others had marvellous escapes.

The White Swan Hotel, Hebden Bridge, was considerably damaged and set on fire by a gas explosion on 11th inst., two occupants being sadly injured.

A house in Vance Road, Blackpool was damaged by a gas explosion on 10th inst.

Electricity in the Brewery.—Mr. Councillor Greenwood, of Hanson Lane, Halifax, has introduced electric motors into his brewery for driving hoisting, pumping, and other machinery, the necessary electrical plant being supplied by Messrs. J. Sunderland & Co.

Appointment Vacant.—The Vestry wants an assistant electrical engineer to take charge of the running of the electric light station on one of the shifts. The salary to be paid is £2 5s. per week, and a note of a few of the things the man appointed must know, and be prepared to do for this princely salary, and what not to do, will be found among our "Official Notices."

Electric Motors in Shipbuilding.—Messrs. Short Brothers, shipbuilders, of Sunderland, are now using electricity for running a portion of their machinery.

Marriage.—Mr. Joseph Crossland, the manager of the Telegraph Manufacturing Company, was last week married at St. Paul's Church, Helsby. Various presentations were made by the staff and officials, and among the long list of presents published in a provincial paper we observe the names of Dr. and Mrs. Mullineux Walmsley and Mr. W. Lynd.

Appointment.—Mr. Hansom, of the Hampstead central station, has been appointed assistant electrical engineer at Bedford, at a salary of £135 per annum.

The Electric Light in the Royal Navy.—Great bodies move slowly, and the Lords of the Admiralty cannot be accused of being at all precipitate with regard to the introduction of electricity into the Royal Navy. A service contemporary remarks :—"The electric light is now universally admitted to be essentially the light for a warship; yet, curiously enough, our Admiralty, while spending so many thousand pounds on refitting the *Sultan*, neglected to lay out the comparatively small additional sum that would have sufficed to give her this modern requirement."

A Secretary in Trouble.—At the Bournemouth Police Court, on Thursday last, Edward C. Offer was charged, on a warrant issued several months ago, with embezzling £420 belonging to Bournemouth District Electric Supply Company, between January, 1893, and March, 1896, during which time he had held the post of secretary to the company. Offer disappeared from Bournemouth just prior to the issue of the warrant, and was arrested at Gillingham, Dorset, on Wednesday. He was remanded.

Electrical Engineering in Sweden.—An important electrical power transmission plant has lately been put down at the Bongbro Iron Works in Sweden. Water power is utilised, the generating plant comprising two 50 H.P. turbines, and three three-phase dynamos. The electrical energy generated is used to drive a plate-rolling mill and a billet mill, to each of which a large electro-motor is connected.

"Röntgen" Rays in 1847!—A *Scientific American* correspondent points out, under the heading, "Nothing New under the Sun," that in the June 5th, 1847, issue of that journal appeared an announcement to the effect that a Belgian *savant* had "just discovered that electric light directed on the human body makes it so diaphanous as to enable the arteries, veins, and nerves to be seen at work, and their action to be studied." Although, adds the correspondent, Crookes tubes were not mentioned, it is possible that some similar device was used, in the then undeveloped state of electrical science. It would be interesting to know who the Belgian *savant* was.

NEW COMPANIES REGISTERED.

Mourdick & Cameron, Limited (3,290).—Registered at Edinburgh, September 7th, with capital £20,000 in £1 shares, to carry on the business of contractors, wrights, ironmasters, mechanical and electrical engineers and commission agents. The subscribers (with one share each) are:—T. Mourdick, St. Rollox, Glasgow, engineer; J. E. Cameron, St. Rollox, Glasgow, engineer; W. Rae, St. Rollox, Glasgow, engineer; H. Steven, Welton Iron Works, Glasgow, iron master; W. G. Dun, Royal Crescent, Glasgow, M.D.; J. Menzies, Phœnix Tube Works, Glasgow, tube manufacturers; C. G. Williams, Progressive Works, St. Rollox, Glasgow, cashier. The first directors shall be H. Steven, J. Menzies, W. G. Dun, T. Mourdick, J. E. Cameron, W. Rae, and E. Martin. Qualification, shares to the value of £50. Registered by Steven and Brownlie, writers, 145, St. Vincent Street, Glasgow. Registered office, 50, Charles Street, St. Rollox, Glasgow.

James Hincks & Sons, Limited (49,356).—Registered September 8th, capital £80,000, in £1 shares, to acquire the business of lamp manufacturers, carried on by a company of the same name now in liquidation at Birmingham, to adopt an agreement with the said company, and to carry on the business of manufacturers of, and dealers in, all kinds of lamps, stoves, brackets, dies, medals, candelabra, gas and electric light fittings, table and other ornaments, machinery, plant, &c. The subscribers (with one share each) are:—J. Hinks, The Cedars, Edgbaston, Birmingham, gentleman; J. Hinks, Milverton Lodge, Leamington, J.P.; A. Ludlow, Beech Hill, Wylde Green, miller; H. Hinks, Milverton Lawn, Leamington, manufacturer; G. Coles, Clarence House, Lozells, Birmingham, secretary; B. Hichs, Nilverton Lawn, Leamington, manufacturer; J. Glover, Kilby House, Leamington, J.P. The number of directors not to be less than three, nor more than seven. The first are:—J. Hinks, Jos. Hinks, A. Ludlow, H. Pllason, J. Glover and H. Hinks, 800 shares; remuneration, £500 per annum divisible. Registered by Waterlow Brothers and Layton, Birchin Lane, E.C.

Stewart Electrical Syndicate, Limited (49,378).—Registered September 10th with a capital of £1,200, in £1 shares, to enter into an agreement with W. N. Stewart to manufacture, sell, and supply electric arc lamps, electric incandescent lamps, and electrical apparatus generally, and to carry on the business of suppliers of electricity, electricians, electrical and mechanical engineers, &c. The subscribers (with one share each) are:—J. E. Hulbert, Sutton Lodge, Theydon Bois, merchant; W. N. Stewart, 58, Friday Street, E.C., merchant; H. H. Wells, 16, Paternoster Row, E.C., solicitor; E W. Rogers, 4, Farlow Road, Putney, clerk; W. J. Heath, 21, Bride Lane, E.C., engineer; T. Dott, 22, Billiter Street, E.C., merchant; C. G. Hayman, 53, Bread Street, E.C., warehouseman. Registered without articles of association. Registered office, 16, Paternoster Row, E.C.

CITY NOTES.

The London Electric Omnibus Company, Limited.

The statutory meeting of this company was held yesterday at Winchester House. We imagine the directors did not expect a very large attendance, for the room engaged was not nearly large enough to accommodate, with any degree of comfort, those who put in an appearance. The chairman (Major S. Flood Page) interested his hearers with a lengthy speech, in which he showed the history of the horseless carriage movement from the year 1831 up to the present time. He quoted from the statements of a Parliamentary Committee which sat many years ago *re* steam carriages, and paid a tribute to Mr. Shaw Lefevre, Mr. Chaplin, Sir David Salomons, and others who had during the past year or so taken so active an interest in the matter, and who were mainly responsible for the Act which comes into force in November next. His thorough grasp of the situation seemed to delight those of his audience who were not already acquainted with the history. He was singularly fortunate in having a splendid topic with which to play upon the minds and the imagination at a statutory meeting. He drew a charming picture of the progress of electric tramways in the States during the past few years, and was assured that the electric omnibus business using accumulators would make equal progress in a very short time. He quoted statements made by Mr. C. P. Elieson, the E.P.S. Company, and others showing that considerable progress is being made in reducing the weight and increasing the output of secondary batteries. This, and like information, made shareholders congratulate themselves upon being so fortunate as to be shareholders in so promising a pioneer company. The company has its own accumulator, said by experts to be the best which has ever been used for the purpose, but the directors were open to use any better one that came along. The experience of Mr. Ward in electrical work, and particularly this section of it, was very considerable and valuable, and Mr. C. E. Spagnoletti, who was one of the oldest electrical men in this country, was also referred to. The chairman said that the company was a pioneer company, and every penny was being carefully husbanded. He further promised the shareholders that, so soon as the board came to the conclusion that they could not succeed, they would tell them immediately. He had supreme confidence, first, that electricity would hold its own, and second, in as much as they had details of improvements far in excess of that of any other people, he believed that they would be able to secure a large share of the work to be done by electricity. The electrical omnibus and vehicle was a natural development of electrical industry. The position of the company was that they had issued 50,000 ordinary shares and the deferred shares. They had the omnibus almost ready. It is not quite complete, but it is nothing like the omnibus that the board thought it was going to be when the company started. The improvement is incredible. The bus had been entirely reconstructed. It would be "the best, easiest, and most comfortable omnibus that had ever been seen in the world." There would be practically no vibration, and hardly any—if any—noise. They were going to complete more of these omnibuses, and put them on the streets. Mr. Spagnoletti would have placed before him every opportunity of checking every item of expense, and he would report to the directors. This outside report, in addition to the statements of the staff, would prove that there was no mistake. They hoped to be able to do this electricity at 2½d. per mile. One company was stating that it was possible to do it for 2d. Mr. C. E. Spagnoletti, in a brief speech, endorsed the gallant Major's statements regarding the battery, the bus, and Mr. Ward, and also congratulated the company upon having so able a chairman. The usual vote of thanks, moved and seconded by shareholders, concluded the proceedings.

Official Announcements re Limited Companies.

Notice is filed in the *London Gazette* for Tuesday last, September 15th, to the effect that certain companies, including the following, have been struck off the register, and are accordingly dissolved:—

American Insulated Wire Company.
American River Electric Power Supply Company.
Carbon Battery Company.
Central Rail Traction Company.
Colne Engineering Company.
Commercial Electricity Supply Company.
Day's Gas Engine Company.
Electric Clock Company.
Electric Semaphore Signal Syndicate.
Elieson Accumulator (British patent) Syndicate.
Industries and Iron, Limited.
London Electric Manufacturing Company.
London Mica Importers.
Merionethshire Electric Lighting Power and Appliance Company.
Metal Reduction Company.
New Electro-Metallurgical Syndicate.
Norris's Magnetic Embrocation.
Putney Electric Supply Company.
R. C. Cutting Douglass and Company.
Saycee Electrical Syndicate.
Smokeless Boiler and Engineering Company.
Theatre Electrical and Specialities Production Company.
Tramway Motor Company.
United Electric Sewage and Chemical Syndicate.

It is also announced that at the end of three months from September 11th, unless cause is shown to the contrary, the Canterbury Electricity Supply Company will be struck off the Register.

Babcock and Wilcox, Limited.

The fifth ordinary general meeting of this company was held last Friday, at the Cannon Street Hotel, E.C., Mr. Andrew Stewart presiding.

The Chairman said that during the financial year from July 1st, 1895, till June 30th, 1896, they had been able to pay:—1. An interim dividend for the half-year ending December 31st, 1895, at the rate of 5 per cent. on the preference shares, and a dividend of 5 per cent. on the ordinary shares, amounting to £10,000. They proposed to pay for the half-year ending June 30th, 1896, a dividend at the rate of 6 per cent. on the preference shares, and a dividend of 10 per cent. on the ordinary shares, amounting in all to £17,000, making 15 per cent. on the ordinary shares for the year. They had placed to the reserve fund the sum of £25,000, and had carried forward £5,276 14s. 3d. They had during the past year exploited new markets, increased the sales considerably in the older markets, and have fairly assured evidence of prosperity in the present year. They had been successful in acquiring ground and buildings at Renfrew, not far from the present works, on which they had built new works and extended the old. In these works, machinery and tools of the most modern and improved character had been erected, by which they hoped to increase their productions, and make them more economically and more perfect. They hoped to have every branch of the manufacturing in full operation in a short time.

The report was adopted, dividends declared, and Sir Wm. Arrol re-elected a director.

The Direct Spanish Telegraph Company, Limited.—The board has decided to pay, in addition to the dividend at the rate of 10 per cent. per annum on the preference shares, an interim dividend at the rate of 4 per cent., free of income-tax, on the ordinary shares, both for the half-year ended June 30th, 1896.

Royal Electric Company of Montreal.—The Bank of Montreal will pay, on and after October 1st, the coupons then due on the 4½ per cent. debenture loan for £154,000 of the above company.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending September 13th, 1896, were £835; week ending September 15th, 1895, £808; increase, £27; total receipts for half-year 1896, £10,016; corresponding period, 1895, £9,316; increase, £700.

The Liverpool Overhead Railway Company. The receipts for the week ending September 13th, 1896, amounted to £1,262; corresponding week last year, £1,278; decrease, £16.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation, Sept. 9th.	Closing Quotation, Sept. 16th.	Business done during week ended Sept. 16th, 1896. Highest.	Lowest.
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	4 %	4 %	4 %	100 —104	100 —104	...	...
25,000	Amazon Telegraph, Limited, shares...	10	...	...	...	8½— 9½	8½— 9½	...	...
1,012,880£	Anglo-American Teleg., Ltd.	Stock	£2 11s.	£2 2s.	£2 9s.	52 — 54	50 — 53	53	52
2,993,560£	Do. do. 6 % Pref.	Stock	£5 2s.	£4 4s.	£4 18s.	97½— 98½	97 — 98	98½	97
2,993,560£	Do. do. Defd.	Stock	...	...	...	9¼— 9⅜	8⅜— 9¼	...	...
130,000	Brasilian Submarine Teleg., Ltd.	10	6½% §	7 %	...	15½— 15⅝	15½— 15⅝	15⅝	...
75,000£	Do. do. 5 %, Debs., 2nd series, 1906	100	5 %	5 %	5 %	112 —116	112 —116	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	... §	2½%	4 %	3½— 4	3½— 3⅝	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	160 —170	160 —170	160	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 % §	1½%	1½%	⅛— ¼	⅛— ¼	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12½— 13½	12½— 13½	13	12⅝
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	20½— 21½	20½— 21½	...	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	3½— 4½	3½— 4½	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 10½	10 — 10½	...	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000 ...	50	...	4½%	4½%	107 —110%	107 —110 %	...	...
60,710	Direct United States Cable, Ltd.	20	2½% §	2 %	2¼%	9⅝— 10¼	9⅝— 10¼	9⅞	9⅝
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½%	6½%	18 — 18½	18 — 18½	$18\frac{7}{16}$	$18\frac{3}{16}$
70,000	Do. 6 % Cum. Pref.	10	6 % §	6 %	6	18½— 19½	19 — 20	19⅜	...
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	5 %	104 —107	104 —107	...	...
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	4 %	131 —134	131 —134	134	132
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	18 — 18½	18 — 18½	18⅝	...
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5 %	100 —104	100 —104	101½	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5 %	101 —104	101 —104	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4 %	130 —133	130 —133	132½	...
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5 %	101 —105	101 —105	...	...
107,600£	Do. do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5 %	102 —105	102 —105	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4 %	106 —109	106 —109	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4 %	111 —114 %	111 —114 %	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4⅝% §	4½%	4½%	11½— 11⅝	11½— 11⅝	11⅝	$11\frac{7}{16}$
180,042	Do. do. 6 % Pref.	10	6 % §	6 %	6 %	18 — 18½	18 — 18½	18¼	18⅛
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅝%	8⅝%	10 %	24 — 25	24½— 25½	...	...
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	104 —107	104 —107xd	106½	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	53 — 56	53 — 56	55½	...
100,000£	London Platino-Brasilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6 %	109 —112	109 —112 xd	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000... ...	5	4 %	4 %	...	2 — 2½	2 — 2½	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 % §	5 %	5½%	7½— 7¾	7½— 7¾	7¾	$7\frac{11}{16}$
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	17 — 19	17 — 19	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	17 — 18	17 — 19	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6⅞— 7⅛	6⅞— 7⅛	7⅛	7
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	107 —110	107 —110	109½	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	4½%	5 %	⅜— ⅞	⅜— ⅞	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	108 — 111	108 —111	...	...
11,839	Reuter's Ltd.	8	0 %	*nil*	5 %	7 — 8	7 — 8	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	140 —145	140 —145	...	...
58,000	United River Plate Teleph., Ltd.	5	...	3 %	4 %	3½— 4½	3½— 4	...	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	5 %	101 —106	101 —106	...	...
15,509	West African Teleg., Ltd., 7,501 to 23,109	10	*nil*	*nil*	4 %	5 — 6	5 — 6	...	...
238,300£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	102 —105	102 —105 xd	104	...
30,000	West Coast of America Teleg., Ltd.	10	*nil*	*nil*	*nil*	1 — 2	1 — 2	1	...
156,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	8 %	99 —104	99 — 104	99	...
64,248	Western and Brasilian Teleg., Ltd.	15	2½%	3 %	3 %	8⅜— 9¼	8⅜— 9¼	8⅜	...
33,129	Do. do. do. 5 % Pref. Ord. ...	7½	5 %	5 %	5 %	7 — 7½	7 — 7½	...	...
33,129	Do. do. do. Def. Ord.	7½	...	1 %	1 %	2¼— 2⅝	2¼— 2⅝	...	...
165,200£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	6 %	103 —107	103 —107	...	...
206,400£	Do. do. do. do "B," do.	100	6 %	6 %	6 %	103 —107	103 —107	...	...
88,321	West India and Panama Teleg., Ltd.	10	¾%	¾%	¾%	1¼— 1½	1¼— 1½	1⅜	1¼
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	11½— 12	11½— 12	11⅞	11½
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	9½— 10½	9½— 10½	...	...
80,000£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	5 %	108 —111	108 —111	...	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7 %	110 —115	110 —115	...	...
164,300£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	100 —105	100 —105 xd	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	4½%	4½%	5 %	9¼— 9⅜	9¼— 9⅜	9⅜	...
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	5 %	5 %	5 %	7⅞— 8¼	7⅞— 8¼	7⅞	...
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	...	4½%	114 —117	114 —117	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	5 %	5 %	16 — 17	16 — 17	17	16⅝
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	17½— 18½	17½— 18½	...	...
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	132 —136	132 —136	132	...
22,475	County of London and Brush Prov. Elec. Ligtg., Ltd., Ord. 1—22,475	10	...	...	*nil*	8 — 9	8 — 9	...	...
20,000	Do. do. do. 6% Pref., 40,001—50,000 ...	10	...	...	6 %	13¾— 14¼	13¾— 14¼	13¾	...
10,000	Do. do. do. iss. at 2 pm., all paid ...	10	...	...	...	5½— 6½	5½— 6½	6½	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	2½%	3 %	4 %	13 — 14	13 — 14	13½	$13\frac{7}{16}$
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	4½%	120 —123	120 —123	122½	122
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	1 %	2 %	12 — 13	12 — 13	...	...
19,980	*St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	4½%	6½%	7¼%	12 — 13	11¼— 12½	12⅝	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	10 — 11	10 — 11	...	...
50,000	Do. do. 4 % Deb. stock Red. ...	Stock	...	...	...	106 —109	106 —109	...	...
67,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	4 %	5 %	7 %	11 — 12	11 — 12	11½	11⅜

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

§ Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation, Sept. 9th.	Closing Quotation Sept. 16th.	Business done during week ended Sept. 16th, 1896. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	S	5 % §	2½%	...	1⅜ — 1⅝	1 — 1¼	1½	1¼
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 % §	3 %	...	1¾ — 2	1½ — 1¾	1⅞	...
125,000	Do. do. 4½ % Perp. Deb. Stock.	Stock	4½%	4½%	...	110 —113	110 —113xd	112½	...
76,770	Do. do. 4½% 2nd Deb. Stock Red. ...	Stock	...	...	...	97 — 101	97 —101	...	...
9,104	Central London Railway, Ord. Shares	10	...	...	...	10½— 10⅝	10½— 10⅝	...	...
207,649	Do. do. do. £4 paid	10	...	...	...	4⅛— 4⅜	4⅛— 4⅜	...	...
630,000	City and South London Railway	Stock	1½%	1½%	1¼%	51 — 53	51 — 53	52	50
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	3 % §	*nil*	*nil*	2 — 2½	2 — 2½	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	7 %	5 %	5 %	1⅞— 2¼	1⅞— 2¼	2	...
17,139	Do. do. do. "A" Shares 01—017,139	5	7 %	5 %	5 %	3 — 4	3 — 4	...	...
100,000	Do. do. do. 4½% Deb. Stock Red. ...	Stock	...	4½%	4½%	103 —106	103 —106	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	*nil*	5 %	1⅜ — 1⅝	1½ — 1⅝	1 1/16	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	7 %	2⅜ — 3¼	2½— 3	2 11/16	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	3/4 — 1	3/4 — 1	...	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	5/8 — 3/4	5/8 — 3/4	...	...
9,600	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	*nil*	*nil*	10½%	10½— 11½	10½— 11½	...	...
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	6 %	8 %	18 — 19	18 — 19xd	18⅜	18¼
3,000	Do. do. do. 7% Pref.	10	7 %	7 %	7 %	18½— 19½	18½— 19½xd	...	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	...	4½%	110 —115	110 —115xd	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	10 %	10 %	21½ — 22½	21½ — 22½	22⅜	22¼
300,000	Do. do. do. 4 % 1st Mort. Debs.	100	...	...	...	107 —110	107 —110	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	1 %	1½%	2⅝%	13¼ — 13⅜xd	13 5/16 — 13 7/16	...	...
10,000	† Do. do. Pref., £10 paid	10	5 %	5 %	5 %	16⅞— 17⅜xd	16¾ — 17⅜	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	20 %	15 %	40 — 43	40 — 43	42¾	41
150,000	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	104 —107	104 —107	...	...
54,000	Waterloo and City Railway, Nos. 1 to 54,000, £6 paid ...	10	...	...	...	8¼— 8⅜	8¼ — 8⅜	8⅜	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.
Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—8%.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

*Birmingham Electric Supply Company, Ordinary of £5 (£4 paid), 6.
Electric Construction Corporation, 6 % Debentures, 103—106
House-to-House Company (£5 paid), 4¼—4⅜.
Do. do. 7 % Preference, of £5, 8⅜—9¼.
Do. do. 4½% Debentures of £100, 109—111.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 10—10½; 1st Preference Cumulative 6 %, £5 (fully paid), 8—8½.
London Electric Supply Corporation, £5 Ordinary, ⅞—1⅛.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 7½—8.

* From Birmingham Share List.

Bank rate of discount 2½ per cent. (September 10th, 1896).

SMALL ELECTRIC LIGHTING PLANTS FOR COUNTRY HOUSES.

Although a great deal has been done towards popularising the use of electric lighting from town mains wherever the supply is available and notwithstanding that innumerable country seats of noblemen and gentlemen are provided with independent machinery for a similar purpose, still, those whose number is legion (in a freehold of a value of from £1,000 to £3,000, according to locality), though finding suitable accommodation for their domestic arrangements, where comfort is aimed at whilst luxury and extravagance are avoided, hesitate to even make enquiries concerning the electric light. This is because an idea exists that the prime cost and working expenses make it prohibitive, and so dependence for light is placed on oil lamps, which are always a great source of danger from fire or explosion as well as frequently the cause of inconvenience from smell and smoke of a most objectionable nature. It is the purpose of this article to put before these freeholders particulars of an installation in a house of the above description which we recently visited in a rural district in South Wales, hoping that with the facts before them, the fallacious idea of prohibitive costs may be abandoned and the adoption of the electric light secured, or at least that fair consideration be given it, now that it works out at such reasonable figures. The installation referred to is at Waunarlwydd House, Gowerton, and was carried out by Messrs. J. C. Howell, Limited, of London and Llanelly. It consists of an oil engine, a dynamo, an accumulator and a switchboard, all contained in a space of 14 feet by 6 feet 6 inches, and of such simplicity that any intelligent person can undertake to work it after being given a few words of instruction, the gardener usually being the man selected. To set the machinery going occupies about ten minutes, and it will then work and continuously charge the accumulator, only requiring attention at intervals of two hours to see that the lubricators on the bearings are fulfilling their duties and to finally stop the machinery after about a ten hours' run when the accumulator is full. This represents during the summer months a three days' supply, or practically means running the engine twice a week, and during the winter months, when lamps are lighted earlier, three times a week. There are in all 25 lamps, arranged as follows: dining and drawing rooms, five each; morning room, hall, kitchen, scullery, pantry, landing, bath room and w.c., one each, four bedrooms and dressing room, seven; all the lamps have the switches for lighting them placed near the door or elsewhere, as was found most convenient, for to have the switches conveniently placed is a source of considerable economy, as it gives every facility for turning the light on when required and off again when done with. One pennyworth of paraffin consumed in the engine whilst working puts a supply of electricity into the accumulator that will keep eight electric lamps, each of 16-candle power, burning for one hour, or a larger or smaller number for a corresponding shorter or longer period. Eight lamps, however represent the number usually burning during the evening in the various rooms from the time darkness comes on till they are all turned off, being about three hours per day in the summer and six hours per day in winter. Occasionally nearly all the lights may be required at one time; but having due regard for economy the bill for paraffin is fully covered by an expense of £7 per year, and this is the whole cost of working beyond occupying the gardener's time occasionally for a few minutes which, certainly does not exceed the time usually taken in trimming and filling the ordinary paraffin lamps. The initial expense of supplying all the machinery, material, fittings, lamps, labour, &c., is £200, exclusive only of the building in which the machinery is placed. With new machinery of this description the depreciation for the first five years can be reckoned at nil, and with ordinary care in working no heavy bill for repairs need ever be incurred. No greater comfort can be added to the country house than the electric light. People who look upon it as almost certain to fail occasionally are not thoroughly well informed, as when an accumulator is employed there is absolutely

no possibility of failure and the light is available all over the house day or night whenever required; the danger of fire is avoided, decorations are preserved, and health and happiness increased.

A COMPLETED CHAPTER IN THE HISTORY OF THE ATOMIC THEORY.*

THE great discovery of the law of gravitation was left reasonably complete by its author. The explanation of this fact is obvious. No other force of sensible magnitude complicates the action of gravitation; its law appeals to simple geometrical relations; and the facts had been well observed and reduced to order. Accordingly, by a few numerical comparisons of the hypothesis with the facts, Newton established the truth of his conjecture, so that it has been generally accepted as a law of nature. The first suggestion of the theory was quickly followed by its final triumph.

Very different has been the history of the discovery which most chemists regard as next in importance to that of Newton. The discovery that matter consists of an aggregation of infinitesimal units or individuals was made by Dalton; but the first suggestion of this kind had been made at least twenty-two centuries before Dalton. Leucippus and Democritus were the earliest recorded believers in this doctrine. Epicurus adopted it; Lucretius expounded it in strains of noble eloquence. But all the early suggestions were quite barren and unfruitful for the advancement of science, for no one before the present century was in a position to make any verifiable hypothesis; and science grows by means of hypotheses so closely in touch with facts as to be verifiable. In later times, Leibnitz accepted the notion of a certain kind of atomic structure of matter; Newton accepted, and reasoned soundly upon, a view which Dalton recognised as akin to his own. Kant seems to have adopted the contrary opinion, and to have believed that matter is infinitely divisible. But Bernouilli made the conjecture, which has since been verified, that a given volume of gas consists of a very large number of very small discrete particles, which we now call molecules; and Higgins, an English chemist, a contemporary of Dalton, was the first to apply the notion of atoms to the explanation of chemical phenomena, although he did not think clearly in regard to the weight of atoms, and so formed no useful hypothesis. Accordingly, the net result of twenty-two centuries of thought on this subject was to form a conception of a possible structure of matter, without imagining any way of establishing the truth or error of this conception, or even of gaining any evidence whatever in regard to it. But, if any are inclined to visit this failure with reproach, it is interesting to notice that the first man who was aware of the quantitative relations which are adapted to throw light on the matter did not fail to make the most full and complete use of this knowledge.

Dalton, and not the ancients, ought to be regarded as the discoverer of the atomic structure of matter, because he invented a hypothesis, involving such a structure, which was capable of being so compared with facts as to be proved or contradicted; because he actually began such a comparison of the hypothesis with the facts; and because all the evidence from facts, varied as it has since become, supports the hypothesis substantially in the form which he gave it. He who suggests that a certain benefit is desirable, or who conjectures that it is possible, shall not fail of due credit; but he who *confers* the benefit will receive the credit due the benefactor.

Since Dalton's discovery, much has been done to confirm and enlarge our knowledge of the atomic structure of matter. New evidence has been acquired in favour of it, because the theory has been ready to extend over whole realms of facts of a kind unknown to Dalton, to explain them, to facilitate their study; and also ready to predict facts, unknown till they were sought in consequence of the prediction, but found when they were sought.

The history of the atomic theory for 90 years would fall into several distinct chapters. One of these chapters, not the least interesting of them, would tell of a very large amount of work, some of it of consummate accuracy, of which the object was to attain some knowledge of the nature or construction of atoms. Since the last meeting of our Association in this city, work has been accomplished which, if I rightly judge, has ended this particular chapter. That the chapter may at some future time be resumed is, of course, not absolutely impossible; but for the present it has come to a definite close. My own interest in the matter suggests, and the coincidence in time now mentioned perhaps justifies, my selection of this completed chapter in the history of the atomic theory as the subject of the address which our constitution requires of me this evening.

This chapter naturally concerns more intimately the members of the sections of Physics and Chemistry. To these I can hardly hope to say anything not already well known to them; but members of other sections may, perhaps, not be entirely uninterested in an account of the conclusions reached.

Dalton's theory was founded on three facts. These facts are often called Dalton's laws; one of them, because he discovered it; the others because he first recognised their important relations to chemical theory. One of these is the law of definite proportions: in any chemical compound, the ratio of the components is constant, is invariable, is definite. This truth had been recognised by others; it was finally established as a result of the discussion between Berthollet and Proust, a discussion well worth recalling for the dignified courtesy and simple love for truth shown by both the disputants. A second of these laws of Dalton is the law of equivalent proportions: if two elements, which combine with each other, combine also with a third, then the ratio in which they combine with each other (or a simple multiple of it) is also the ratio of the quantities of those which combine with the same quantity of the third. That this was true, at least in some cases, was known before Dalton. The third law is the law of multiple proportions: if two bodies combine in more than one ratio, those ratios are simple multiples of each other. This truth was discovered by Dalton.

These three laws are statements of *facts*. Careful and multiplied experiments have convinced us that, if these statements are not rigorously exact, their deviation from accuracy is less than the accidental errors of the best experiments used to test them.

Perhaps it is worth while to delay for a moment, in order to state to what degree of precision such experiments have been brought. The degree of precision with which any supposed law can be verified depends on the skill of the investigator, on the instrumental equipment available, and on the conditions of the problem. Often the conditions of the problem impose very stringent limitations on the precision of our experiments. For instance, the truth known as Ohm's law has been verified, in the case of metallic conductors, to one part in a million millions; but in the case of liquid conductors, the conditions are such that the precision attainable so far has been only a millionth as much. Huyghens's law, relating to double refraction, has been verified to one part in half a million, and there seems to be no possibility of attaining any considerable increase in the precision of the observations. These are examples of the very highest degree of precision which has been secured in the verification of supposed laws of nature.

The precision which can be attained in chemical analysis, even of the most elaborate kind, is much less than in the cases just mentioned. The determination of atomic weights is the chemical process in which the highest degree of precision is demanded. If we denote the precision of such determination by the words "good," "excellent," "admirable," "consummate," then we may fairly say that in a good series of determinations the average difference from the mean of all will be less than one-thousandth part of the ratio sought; in an excellent series, less than one three-thousandth part; in an admirable series, less than one ten-thousandth part; and in a consummate series, less than one fifty-thousandth part.

Now, the work of Stas was all admirable in precision, and much of it was consummate, and he made experiments expressly intended to verify the law of definite proportions. The average error in this series of experiments was not more than one part in 30,000; and his result was, that, if the composition of the compounds examined is not rigorously constant, the variations are too small to be detected. The law of equivalent proportions was verified with the same degree of precision; the accuracy of the law of multiple proportions has been thought to be deducible from the truth of the two other laws.

To some such degree of precision, then, Dalton's laws are the expression of facts. With these facts for a guide, and with no theory founded on the facts and explaining the facts, all chemical computations could be made, and chemical formulæ could be established. And, if a theory should be devised, and accepted, and finally overthrown, these facts would remain unchanged for our perpetual guidance. Some of Dalton's contemporaries accepted the facts as a sufficient guide, and refused to burden them with the weight of the theory. Some were engrossed, for the time, in following out practical consequences of the facts; some distrusted conclusions supported by but a single line of evidence; some, perhaps, distrusted the capacities of the human mind. But the facts were accepted.

All scientific men, all sensible men, have a great respect for facts. Perhaps one cannot have too great a respect for facts; but his respect may be wrongly directed. Facts are often very interesting in themselves; they often have an important relation to human welfare; their discovery is often a great intellectual triumph; and we may regard them as the miser regards his gold, forgetting that the most precious use of facts is to help us to see beyond them. Facts are evidence; but we seek a verdict. Facts are a telescope; we desire enlargement of vision, further insight into nature. Facts are openings which we laboriously hew in the walls which shut us in; they cost enough to be valuable, but their real value is in that which they promise or disclose. Facts are a foundation for our building; the structure must rigorously respect the lines of the foundation, but it is a pity to believe that the basement walls are the chief beauty desired by the architect or owner. As Tyndall phrased it in a lecture at Manchester, "Out of experience in science, there always grows something finer than mere experience. Experience, in fact, only furnishes the soil for plants of higher growth."

In the present case the soil was fertile, the finer growth has been rapid and vigorous. Dalton inferred that chemical elements consist of very small units or individuals; that all the units or individuals of any given element are equal in weight, and that combination takes place by the grouping together of different units or individuals. This is Dalton's atomic theory.

In Dalton's time there was no fact opposed to this novel conclusion; but there was no second set of facts to support it. The progress of chemistry depended on making due use of Dalton's three laws, and they were quickly and generally accepted; but whether the hypothetical chemical units or individuals actually exist or not, although a most interesting question, did not press for instant decision. Most chemists regarded with favour the idea of the actual existence of the chemical units or individuals. Dalton called them atoms, and perhaps the name brought misfortune; for many thought that the new theory was, that matter is made up of units or individuals which cannot be divided by any possible force. The word "atom," the word "indivisible," like the word "individual," properly mean that which is not divided in the phenomena considered. An absolutely indivisible atom, like an irresistible wave or an immovable rock, can be spoken of to puzzle children, but for adults, as Clifford

* Address by the retiring President of the American Association for the Advancement of Science at the Buffalo Meeting. Reprinted from New York *Science*.

said: "If there is anything which cannot be divided, we cannot know it, because we know nothing about possibilities or impossibilities; only about what has or has not taken place." I judge that many, probably most, chemists and physicists understand the word atom correctly; many other understand it to mean that which cannot be divided by any possible force, and so misunderstand it. For instance, the author of the "History of the Inductive Sciences" failed to understand the word as chemists and physicists understand it, and so supposed that he rejected the atomic theory. Many chemists would reject the theory that matter consists of very small units which *cannot* be divided. I suppose that very nearly all believe that matter is made up of small units which are not divided in any chemical or physical change yet observed. This is the atomic theory of Dalton.

A few years after Dalton had formed the atomic theory, and had obtained the first experimental evidence on a matter which had enlisted attention for more than 2,000 years, Davy showed, by brilliant experiments, that certain bodies were compounds, although they had resisted all previous attempts to decompose them. Since the first use of electricity had so important results, men were ready to suspect that even supposed elements might ultimately prove to be compounds. It was therefore in a congenial soil that Prout's hypothesis took root. Trusting to experiments of not much accuracy, Prout suggested, in the year 1815, that probably the atomic weights of other elements were divisible, without remainder, by the atomic weights of hydrogen; or, in other words, that they are whole numbers, if the atomic weight of hydrogen be taken as unity.

The new suggestion was most attractive, for two reasons: On the one hand the truth of the new suggestion would lead to a very great practical advantage. The labour of determining atomic weights would be immensely simplified and lessened if we could know beforehand that the numbers to be found were integers. And on the other hand, the new suggestion, if approved, would promise a most interesting and valuable hint as to the nature of matter and the structure of atoms. If, for instance, the atoms of carbon and nitrogen and oxygen weigh precisely as much as 12 and 14 and 16 atoms of hydrogen, then it is a very plausible hypothesis that each of these atoms is really composed of the material of 12 and 14 and 16 atoms of hydrogen, compacted into a new atom. Davy had led many to suspect that perhaps some atoms might be compound, and the new suggestion, looking in the same direction, was received with great favour by many, among whom were great discoverers and great experimenters, and great teachers of chemistry. In England, where Davy and Prout both lived, Thomson had great influence. It was Thomson who, in the *Journal of Chemistry*, of which he was the editor, first announced Dalton's discovery. Thomson wrote the history of chemistry. Thomson's "System of Chemistry" was thought worthy of translation into French at a time when French was the mother tongue of chemistry. And Thomson accepted Prout's hypothesis as probably true. But Turner made more accurate and more numerous determinations of atomic weights than any other English chemist; and he rejected Prout's hypothesis. Berzelius, the great Swedish chemist, whose determinations of the atomic weights of all the elements then known were regarded with so much admiration by all chemists, pronounced Prout's hypothesis a pure illusion. But Dumas, than whom none in France stood higher, whose opinion had great weight on account of the excellence of his many determinations of atomic weights, accepted Prout's hypothesis with a slight modification, and believed that his experiments had established its truth. Stas, the distinguished pupil of Dumas, began his work with a bias in favour of the hypothesis; but when his first series of admirable determinations of atomic weights was published, he pronounced the hypothesis a pure illusion, entirely irreconcilable with the numerical results of experiment. But Mallet, who has made several excellent determinations of atomic weights, and Clarke, who has recomputed and reduced to order all the published determinations, declared themselves forced to give Prout's hypothesis a most respectful consideration. It is obvious, then, that 10 years ago it was not finally settled whether the hypothesis was or was not true.

The hypothesis, then, has disappointed our hopes of any practical advantage in conducting to a knowledge of the exact value of any atomic weight. But, nevertheless, the hypothesis has not been neglected. As was said, if it is true, we may expect from it new insight into the nature of atoms. Accordingly, an immense amount of labour has been expended in attempting to determine whether the atomic weights of certain elements are or are not divisible without remainder by the atomic weight of hydrogen. Now, since our last meeting in this city results have been attained which show that further effort in this direction is not justified by the hope of any theoretic advantage. The chapter has come to an end. Prout's hypothesis cannot be proved by experiment.

When we attempt to decide by experiment whether Prout's hypothesis is true, the nature of the problem, and the limitations of our present knowledge and of our available manipulative skill, impose three conditions to which we must conform.

In the first place, we can more readily test the correctness of Prout's hypothesis by determinations of the smaller atomic weights. The reason is obvious. All analytical work is affected with some accidental error or uncertainty. When Herschel wrote his admirable "Discourse on the Study of natural Philosophy," he said that it was doubtful whether we could depend on the result of a chemical analysis as having an uncertainty less than one part in 400. Work of much greater accuracy has been done since this statement was made; but, for the moment, let us assume that, even now, the uncertainty of a determination of an atomic weight is a four-hundredth part. This uncertainty affects a large atomic weight much more unfavourably for our purpose than it affects a small atomic weight. For instance, Stas found the atomic weight of lead to be 206·91, if we take the atomic weight of oxygen as 16·00. The assumed uncertainty, one four-hundredth part of this, is 0·53; so that, on our assumption, the true value is somewhere between 206·38 and 207·44. These numbers differ more than a unit; no one has a right, on this showing, to assert that true value is the whole number, 207·00, nor that it is not so.

But a small atomic weight may be much less unfavourably affected by the same proportionate uncertainty. For instance, recent determinations show that the atomic weight is 15·83 when the atomic weight of hydrogen is taken as unity. The assumed uncertainty, one four-hundredth part of this, is 0·04, so that, on our assumption, the true value is between the limits, 15·84 and 15·92. These numbers differ by only one-twelfth of a unit, and both of them differ much from the nearest whole number, 16·00. It is, therefore, by determinations of small atomic weights that we may hope to decide the truth of Prout's hypothesis.

But among the smaller atomic weights, some, in the present state of our knowledge, can be more accurately determined than others. Accordingly a second condition imposed on us by the limitations of our knowledge is that we must determine, with what precision we can, those small atomic weights which admit of the maximum of precision. There are eight atomic weights upon which, with the experimental data now available, the decision of the matter may be fairly made to depend. These elements are lithium, carbon, nitrogen, oxygen, sodium, sulphur, chlorine and potassium; the atomic weights are, in round numbers, 7, 12, 14, 16, 23, 32, 35 50 and 39. If numerous and careful experiments show that these atomic weights are whole numbers, Prout's hypothesis has a solid basis in fact; if seven are whole numbers, and the other is 35·50, then Dumas's modified statement of the hypothesis has a solid basis in fact, for 35·50 is divisible without a remainder by *half* the atomic weight of hydrogen.

One more condition is imposed on us by the limitations of our knowledge and manipulative skill. Our experiments determine most atomic weights, not with reference to hydrogen, but with reference to oxygen. Experiment, for instance, does not determine directly that the atomic weight of lithium is seven times that of hydrogen, but that it is seven sixteenths that of oxygen. If the atomic weight of oxygen is uncertain, the atomic weights of the other seven elements, with reference to hydrogen, are all uncertain in the same proportion, although with reference to oxygen they are now determined with very small uncertainty. Accordingly, the third condition imposed on us in attempting to learn the truth about Prout's hypothesis is that the atomic weight of oxygen must be well determined.

It may be remarked that it would be a great gain, as all chemists will see, if several other atomic weights could be determined by direct comparison with hydrogen, provided the precision attainable was of the degree which I have called admirable, or even excellent. Now, methods have been devised by which the atomic weights of lithium, sodium and potassium, as well as of several other metals, could be referred directly to hydrogen, by experiments which present no great difficulty and which are capable of the required precision. Further, a method has been devised by which the atomic weight of chlorine can be determined with direct reference to hydrogen, by experiments capable of the required degree of precision, but involving considerable difficulty in manipulation. But, until some such methods shall have been employed by some one, we must be content with the inferences which can be drawn from data of the kind now available, which depend on our knowledge of the atomic weight of oxygen as the corner stone of the system.

Our knowledge of the atomic weight of oxygen ten years ago depended largely on the experiments of Dumas. His results differed from the whole number 16·00 by one four-hundredth part; he himself judged that the uncertainty remaining might be one two-hundredth part. If we accept this estimate of uncertainty, we may say that he proved that the atomic weight of oxygen is included between the limits 15·88 and 16·04. No one could assert that the true number is, or that it is not, the whole number 16·00. A proportionate uncertainty, therefore, existed in the other seven atomic weights just mentioned. Accordingly, 10 years ago we could not well discuss the question whether these atomic weights were divisible, without remainder, by the atomic weight of hydrogen.

The atomic weight of oxygen is, accordingly, doubly important for our purpose. The atomic weight is a small one, well adapted to aid in the solution; and, further, many other atomic weights, also well adapted to aid in the solution, depend on a prior knowledge of this constant. It is for this two-fold reason that the work done since our last meeting at Buffalo is important and interesting. The members of this Association have not failed to take upon themselves a fair proportion of the considerable labour involved.

Since that time not less than ten or eleven independent determinations of the atomic weight of oxygen have been successfully concluded.

Cooke and Richards were the first to complete and publish their result; they used a new and ingenious process. Keiser was next; he employed a method for weighing hydrogen, which he had independently invented (though it had been previously invented elsewhere), which is the best yet used. In both these series of experiments the hydrogen was combined with oxygen by manipulation something like that of Dumas; but the improvement which permitted the direct weighing of the hydrogen made the essence of the process novel. Then Noyes devised a new method of weighing hydrogen directly, and a new manipulation for combining it with oxygen, and carried out the process in an apparatus having the advantage of great simplicity. Further, since our last meeting the Smithsonian Institution has published a work containing three series of determinations of the value in question.

In England, Lord Rayleigh used another novel method of combining oxygen and hydrogen, in which he weighed both elements in the form of gas. He also made two series of determinations of the ratio of the densities of the gases. Scott determined the ratio of the volumes of the gases which combine, in several series of experiments of great accuracy. Dittmar and Henderson rendered an

important service by repeating, with many modifications, the experiments of Dumas; with the advantage which the later experimenter commonly has over the earlier, they were able to secure a much higher degree of precision and to eliminate the sources of constant error which Dumas detected too late.

In France, Leduc repeated the experiments of Dumas, and also determined the ratio of the densities of the two gases.

In Denmark, Thomsen has applied a different process, in which the atomic weight of a given metal is compared with those of oxygen and of hydrogen successively.

We have, then, eleven series of determinations of the atomic weight of oxygen. One of these, for reasons which, so far, are chiefly matter of conjecture, differs much from the mean of all the others. These other ten are concordant; they differ, on the average, only one part in 2,200 from their mean, and the greatest difference from the mean is about one part in a thousand.

(To be continued.)

APPLIED ELECTRO-CHEMISTRY.

By JAMES SWINBURNE.

Cantor Lecture I.—Delivered before the Society of Arts, April 27th, 1896.

Introduction.

There is probably no branch of industry which is developing so rapidly as electro-chemistry. It might have been thought that this development would have begun 10 years ago, as the electrical engineer was then quite able to provide economical steam dynamos. As a matter of fact, inventors have been working at electrolysis and electro-chemical processes for more than half a century, but a large proportion of these were unpractical, as is sufficiently proved by their working out methods involving cheap electrical power when there was no prospect of such a thing. For the last 10 years or so, the applications of electricity to chemical manufacture, and to metallurgy, have engaged the attention of a great many very able people, and a still greater number of the class the Americans expressively call "cranks." A considerable time-lag was to be expected, for it takes quite 10 years for people to realise that electrical power can be developed at high efficiency and low cost. Even now the average mechanical engineer does not appreciate the value of the electric motor; so it is hardly to be expected that chemical manufacturers can yet all fully realise exactly what electrical power will do. All the same, they have been by no means behindhand, and there are several large electro-chemical works already running in different parts of the world.

Some years ago the difficulty was that the average electrician knew no chemistry, and the chemist knew nothing about electricity; so that there was a sharp line between electricians and chemists. There is, however, a new state of things arising. During the last 15 years a new science may be said to have come into existence. This is chemistry on an engineering basis—that is to say, chemistry is now studied in its relation to the transformation of energy. This study demands almost a peculiar training. It requires a knowledge of mathematics and of thermo-dynamics, and mathematics is not generally a strong point among chemists. It also needs a knowledge of electricity, and of general physics, and, of course, of chemistry. The result is that what I have called engineering chemistry, or chemical energetics is not the work of the older chemists or physicists, but, with few very eminent exceptions, is largely in the hands of a number of comparatively young men, who are not trammelled by older ideas, and who are specially fitted by their training in chemistry, physics, and mathematics to deal with this subject.

Splendid work has been recently done in physical chemistry and the theory of electrolysis in Germany, and that country has distinctly taken the lead in both theoretical and applied electro-chemistry. But the result is that there is a gradual development of two distinct classes of electro-chemist. One the purely scientific, who does not know the price of anything, and could not tell a buddle from a jigger; and the other who never heard of the Kupferferro-cyanidniederschlagsmembranerscheinungen—I think that word is approximately correct. It is men of the last class that are doing the practical invention, and are getting capital and setting up factories. But the first class must not be regarded as useless. Like all purely scientific men, they are providing the raw material for the practical technologist to work up into the finished article for the use of man. It is, however, a great misfortune that the two kinds of knowledge cannot be more often combined in the same man; and the present tendency is towards more complete separation, which is to be deplored.

Electricity is being gradually applied to many branches of metallurgy; and to various processes of chemical manufacture, chiefly inorganic; there are also signs of its development directly and indirectly in the manufacture of organic products. Electricity is also used as a means of getting very high temperatures in the electric furnace, and though in such cases the reaction is generally a mere reduction by carbon, and not electrolysis at all, their description may be classed under electro-chemical work.

It would be clearly impossible to give any account of even the theory of electrolysis, or the practice of it alone in four short lectures. It was, therefore, very difficult to know how to give a short course on such a subject. As experiments are an important feature in the Cantor lectures, and as the only conceivable reason for anyone's coming to a lecture—unless he has to give it—is to see experiments which he cannot see elsewhere, and which cannot very well be described in print, it seemed best to show as many experiments as possible. The subject, however, does not lend itself very well to lecture demonstration, and, therefore, as many experiments as possible—especially new ones—were chosen, and the lectures were arranged and delivered very much to suit the experiments. As these would hardly read well, the printed lectures are different, and include very little of the delivered matter, being practically independent. As just explained, it would be impossible to go over the whole ground, even very shortly, so I will merely touch on a few points that seem to me interesting, without attempting to follow the lectures delivered, or to give any sort of general survey of the subject. Up to now, the Cantor lectures have been not only exceedingly valuable in themselves, but the lecturer has frequently changed into an author, and the series of lectures grown into a book. If it is ever my fortune to develop these lectures into a book, I shall then at least have room to give a more general account of the subject.

Cost of Energy.

In most electro-chemical manufactures the cost of energy is of cardinal importance. The cost and heating power of the coal is the most important factor. If coal is taken at ten shillings a ton, and gives half an indicated horse-power per pound; and if the combined efficiency of the engines and dynamos is taken at 80 per cent., the coal comes out at 0·18d. per kilowatt hour. In many places coal is much cheaper than ten shillings per ton, without being anything like proportionally worse, so that 0·18d. per Board of Trade "unit" may be taken as quite liberal enough, as far as coal goes. To the cost of coal must be added labour, superintendence, oil, and waste, and the interest and depreciation on the generating plant. These can be covered with a reasonable margin by taking the cost of power as a farthing per kilowatt hour. A great deal depends, however, on precisely what is meant by cost. A farthing per kilowatt hour covers outlay for coal, wages, and stores, and interest and depreciation at low rates on capital and plant. If, however, an engineer were to get out an estimate for the manufacture of some chemical, which was very simple, needing little more than electrolytic tanks and storage and packing; and if he found that the vats and electrolytic department cost, say £16,000 to build and £4,000 as working capital; and that the profit after paying salaries, wages, rent, taxes, office expenses, and after paying for all energy used at the rate of a farthing a kilowatt-hour, was £2,000 a year, he would be quite wrong in saying it would pay 10 per cent. The capital in engines and dynamos must be taken into account and added to the other, bringing it up to say £40,000. Then to the £2,000 must be added the interest on the £20,000 in generating plant, that is included in the farthing, say £1,000. The total profit is thus £3,000 on £40,000, not £2,000 on £20,000; or 7½ per cent. instead of 10.

This example is given to show that a good deal of care is necessary in working out even the roughest estimates. The great difficulty is to know what is meant by cost in each case. If the generating plant belonged to an independent proprietor he would not be likely to supply energy at a farthing per kilowatt-hour. He would reckon his prime cost as a little less than a farthing, and would then add on a considerable percentage to give his selling price. In central station work the cost of energy is enormously greater. This is because the generation does not go on continuously day and night, and because the expenses of distribution and collection as well as the inconveniences of location come in. The cost of energy produced by an electric light station is thus no criterion, as the other expenses run up so enormously that the cost of coal burnt at full economical load is almost buried under a pile of incidental expenses.

Probably the greatest errors in estimating the costs of electrolytic processes are due, not to under-estimating or over-estimating the cost of electrical energy, but to not realising the expenses of handling, packing, finishing, or perhaps purifying the materials. Other things have to be considered, such as the dislike of the trade to anything new, or apparently new. The word "electric" acts like magic in increasing the sale of hair-brushes, quack medicines, and a thousand and one things which have nothing to do with electricity; but these articles are mostly sold to women, or to the more ignorant classes. In commerce, on the other hand, there is an equally ignorant prejudice against anything electric. Electrically tanned leather, for example, is regarded with considerable suspicion, especially as it is somewhat lighter in colour. Even the packing should be the same as that of the goods made in the old way. Some day people may realise that electrically-made chemicals are often more nearly pure than others. This is already commonly understood in the case of high conductivity copper; but then it is chiefly bought by electrical engineers.

In dealing with the cost of electrical energy, the price of coal has here been taken as the basis. There is abundance of water power, however, in many districts, and we must consider how far that may affect the question of cost of manufacture. It is only too frequently assumed that water power costs nothing, and must, therefore, give electro-chemical manufacture an enormous advantage over older processes. This is very far from the truth, however, and the economy to chemical workers of the use of water power has been enormously exaggerated. I say the economy to chemical workers advisedly, for I do not mean that it does not pay well to utilise water power, but that the advantage is to the owner of the waterfall, not to the manufacturer, except in special cases. An example will illustrate this best. Imagine a chemical district where coal is 10s. a ton, and where there is a large use of electrical power (say) for making caustic and bleach electrolytically. Imagine, also, that there is water power in the neighbourhood. If the owners of a chemical works want power, they will apply to the proprietor of the waterfalls. He will by no means make them a present of as much power as they want; on the contrary, he will charge rent; and he will charge as high a rent as he thinks he can get. The chemical makers, on the other hand, will not give a rent that will make the water power as costly as coal, but they will be guided by the least difference, so that the rent asked and obtained will be such that it costs the chemical

company the same for water as for steam power. If the turbines and races which we suppose to be put down by the chemical manufacturers cost about the same as the engines and boilers, and take about the same labour and superintendence as the steam-generating plant, the rent for the water power, apart from the land for the turbines and dynamos, which is a different matter, will be approximately equal to the cost of coal for the same power. Assuming the plant to run continuously, day and night, 1,000 kilowatts generated at 80 per cent. efficiency at 2 lbs. of coal per kilowatt-hour, coal being 10s. a ton, comes to £6,500 a year in round numbers, or £6 10s. per kilowatt year. A water-power of say, 10,000 kilowatts, in such a place, thus corresponds to a coal mine whose yearly output of coal is worth £65,000 before it is touched in the mine, and whose supply of coal is inexhaustible.

Suppose, however, that the water-power is not in the chemical district at all, but in such a place as, for instance, Norway. The chemical manufacturer may be at some disadvantages there. The district may be inaccessible, and the establishment of works there may involve special difficulties and expenses. In such a case the proprietor of the water-power will not ask £6 10s. per kilowatt year, for he has no chance of getting that. He will eventually get some smaller rent, so that it will just pay a new concern to start in Norway rather than England. Still it is the owner of the water-power that gets the advantage from it, not the chemical manufacturer.

Whether it will pay to use water-power in a given place or not depends on how far the power is an important item in the cost of manufacture. In such cases as making aluminium, carborundum, or calcium carbide, the power is by far the heaviest part of the cost of manufacture; and as carriage is a small matter in these cases, such manufactures will be the first to grow in places which have water-power, but which are otherwise inconvenient. In most cases, however, the actual cost of the power is a comparatively small matter, and the inconveniences of being away from supply of raw material, and coal for heating purposes, and from the market and the supply of skilled labour, make it inadvisable to use water-power, even when it can be obtained at a very low rent. Cases like that of Niagara are peculiar. It seems to be the idea that an industrial centre will spring up around the Falls merely to batten on cheap power. There are not very many industries, electrical or non-electrical, in which power plays a very important part, and in most cases it would not pay to start works in a new locality, even if the power were given, as the drawbacks are serious. Thus, for example, it would not pay a cotton spinner to start a new works in Devonshire, even if power were given him there, as he could not get operatives there, and he would be completely out of touch with his markets, both for buying and selling. In other cases the works must be near the raw material, if it is heavy, as in the case of gold mining, or near coal, or near both, as in the case of iron works. In the case of Niagara, it will undoubtedly pay users of electrical furnaces and makers of aluminium to take power from the supply company there, rather than burn coal, as the supply company can always supply power more cheaply than it can be got from coal. Whether it would pay to go to Niagara rather than to any other falls, depends on the terms offered.

The position of water-powers is a little anomalous just at present, because things have not settled down yet. At present the water-powers are not fully utilised, or anything like it; and there are very few processes in which power is the factor of paramount importance in determining the cost. At first, therefore, power can be got for such processes at nominal rents, and it is almost correct in such cases to say the power costs nothing. The farthing per kilowatt-hour, in the case of coal, however, included interest and depreciation on plant, as well as labour and stores. In the case of the waterfall at a nominal rent, the interest on the capital sunk in flumes, races, turbines and dynamos must also be taken into account. The cost of power will then come out a long way below a farthing, unless the fall of the water is very slight, and there are considerable engineering difficulties. In cases like aluminium or calcium carbide, carriage is of little importance. The bauxite or other oxide of aluminium has to be carried in any case, and if it has to go by sea or rail, it does not much matter how far it goes within reason, provided it has not to be handled on the way. The aluminium or the calcium carbide is so valuable in proportion to its weight, that the carriage of the produce to market is not worth considering. There are any number of waterfalls in the United States, Canada, Switzerland and Norway which are available for processes of this nature, so it is probable that such processes will be able to obtain water-power at very low rents for very many years to come.

Turning now to such cases as, for instance, making bleaching powder and caustic soda by the electrolysis of a solution of salt, the number of waterfalls available for this purpose is comparatively small. Suppose the electrolysis vats have a current efficiency of 80 per cent., and take (say) 6 volts per vat, the cost of energy comes out approximately £5 per ton of caustic. Of course this cost must be allocated as to the caustic and bleaching powder, as they are not independent products. We may say £2 10s. per ton of caustic, and £2 10s. for 2·3 tons of bleach, or, roughly, £2 10s. for caustic and £1 a ton for bleaching powder. Even if the whole of this were saved, it would not pay to start a works in an out-of-the-way mountain pass, where the carriage of salt, lime, and coal for finishing, and that of the finished caustic and bleach, would come to far more than £5 for each ton of caustic made. In addition to carriage, superintendence and skilled labour are more expensive in out-of-the way districts. The whole object of life is not to make an income; that is only a means to an end, and a man with anything in him will not exile himself except as a temporary way of making money comparatively rapidly.

The number of water powers at the coast, or n other very accessible places is limited, and there will soon be enough taken up to raise the rent till the chemical manufacturers no longer profit appreciably by it. The result is, that in the immediate future water power will not help the electro-chemist except in such cases as the electrical furnace.

At present, water powers are sometimes to be got cheap, as the owners having so far got nothing for them are glad to sell outright or to give a concession for a number of years for a certain income, rather than await the chances of high rents later on, when electro-chemistry is more developed. In other cases proprietors have already very exaggerated ideas of the value of their property, and it is impossible to deal with them.

It is almost needless to remark that if an electro-chemical company owns a waterfall, it is not in any better position than if it rented it. It has merely sunk some of its capital in the waterfall, and the same rent that would otherwise have to be paid should be charged against the manufacturing account, and credited to the profit account of the waterfall ownership. If the waterfall was bought cheap, owning it may be profitable, but it does not cheapen the electrolysis, as the company might just as well have let their waterfall for a fair rent, and started their works in St. Helen's, or Kalk.

It is needless to say all this is merely elementary economics. I do not carry books on economics with me on a holiday; but if I remember right, it is a simple application of Ricardo's theory of rent.

While on the subject of costs, it may be as well to mention an apparent anomaly which often comes up in making estimates or designing new works. Suppose a process is to be worked, which needs a large steam-generating plant, and suppose that on paper the process is capable of yielding an enormous profit, say 50 per cent., on the capital. It may be safely said that such a process, in practice, will not yield such a large profit, as all sorts of things will go wrong, and troubles will arise in unexpected quarters. Let us assume, then, that in practice even a pessimist, who knows his subject, expects a profit of 25 per cent. to be earned. Then the question arises, What sort of machinery is to be put down? As the engines are to run day and night, the efficiency of the generating plant seems of the highest importance, and the first idea is to put down high-class boilers, with automatic stokers, and triple expansion condensing engines of the best and most modern types, on the ground that, as the engines run continuously, the saving in coal is more than equal to the interest on the extra capital sunk. It must be remembered, however, that the available capital is limited, as, however good the process appears, it is of necessity a large experiment at first. Unless, therefore, the saving by coal will pay at least the same interest on the increased capital as the process will as a whole, it will be better to spend it so as to get a larger output at a lower efficiency. In extreme cases, it may even pay to fit up second-hand marine or other engines at low cost and low efficiency. The same considerations apply to other kinds of plant. In such cases economical working is not so important as it appears at first sight, but freedom from breakdown is of course vital. Old machinery is often very safe from this point of view, if not overworked. When the process is satisfactorily started, and more capital is available, and the profits are falling towards the normal, it will pay to put in the best machinery, and to work at the highest economy, giving the plant a term of many years to repay its extra cost.

While on the subject of costs and estimates, it may be as well to point out another consideration that is frequently overlooked. An electro-chemical process is proposed which is to compete with a large existing chemical industry, and it is assumed that the price will not fall, because if it did fall a little, the chemical manufacturers would fail. The existing steady price of a chemical is such that the badly managed concerns just make it pay, and the well managed works make good profits. The better makers can always lower prices considerably without loss, so that a new mode of manufacture cannot command the market by being able to produce a little cheaper; it can only oust a few of the existing manufacturers. It must be remembered that it will not pay to put down plant for a process that cannot pay interest and depreciation on that plant; but the old makers have already put down their plant, and rather than close as prices fall, it will pay them to write off the whole of their plant as worthless, or rather at its break-up value, and go on, if they make any profit on their working expenses alone, or even if they hope to do so soon. Before a new process can therefore drive an old one out of the market, its profits must at least be greater by the interest, and for some time by the depreciation of the plant engaged in the old manufacture in addition.

Theory.

But little can be said here on such a subject. For most practical purposes, electrolysis may be regarded as a convenient means of bringing about oxidation and reduction. The words oxidation and reduction are used very loosely by chemists, but the idea is generally clear enough. If we wanted to make it still clearer, we might go so far as to describe oxidation as what goes on at the anode, and reduction as what takes place at the cathode. This would give a good idea of the changes meant, and the notion could then be extended to reactions which cannot be, or, at any rate, are not produced by electrolysis.

When we examine the processes employed in commercial chemical manufacture, as well as in the laboratory, we are struck by the fact that by far the largest portion are processes of oxidation and reduction. Nearly all the processes for getting metals consist of reductions. Iron oxide is reduced to get iron. The carbon is then oxidised out in the converter or on the puddling hearth, to get steel or wrought-iron. Zinc sulphide is oxidised first, merely to get it into a form to which reduction is easily applicable. The reduced zinc is then again oxidised, to make white paint. The Leblanc process for making soda crystals and bleach is a maze of oxidations and reductions, with a few substitutions thrown in. The pyrites is oxidised into oxide and sulphur dioxide. There are alternate reductions and oxidations of a complicated nature going on in the acid chambers. The sulphuric acid acting on the salt is a substitution process. Generating chlorine

from the muriatic acid is an oxidation and reduction process, and the absorption of chlorine by lime may be considered another case. The bleach is then sold to oxidise paper pulp, and frequently to oxidise our linen to a regrettable extent. The salt cake is reduced in the black ash revolvers, a substitution going on also, this reaction being really very complicated, and after that there is only lixiviation and crystallisation. It would weary the reader, or we might include the Weldon process as part of the system, and enumerate more oxidations and reductions. We may, however, imagine the carbonate to be reduced by carbon, to give us sodium; and we now have a system involving, without the Weldon process, no less than five separate oxidation and reduction processes to split salt into chlorine and sodium. Electrolysis splits fused salt into chlorine and sodium at once, without any other processes or chemicals being needed, and without any waste. The difficulties in electrolysing fused salt are so great, however, that at present the older and tremendously roundabout processes hold the field. The electrolysis of salt solution is more complicated, as sodium is not obtained, and there are a number of small secondary reactions.

For many purposes, all that the electro-chemist—if such a word could be applied to such a man—wants to know is, how much of a compound is decomposed by a coulomb or an ampere-hour, und what pressure is needed. Faraday's law gives him one of the data; the other is a different matter, as the pressure needed depends not only on the back pressure of the decomposition vat, but also on the resistance of the circuit. The resistance often depends on the current density; for instance, if bubbles of gas are being evolved from an electrode, they insulate it, except for the thin films of liquid separating them. The result is a very high surface resistance. I have tried the effect of gradually increasing the pressure on lead plates in dilute acid. The pressure and current rise together, until something like 3 volts is reached. The current then increases much more rapidly than the pressure, gases being given off in abundance, and between 3 and 4 volts there is a state of things in which a very small difference of pressure produces a given change of current density. The arrangement was used in connection with a resistance in a differential governor and was very sensitive. As many processes, such as the electrolysis of salt solution, involve evolution of gases at the electrodes, it is important to get the most economical results. The mistake is often made in designing vats with the electrodes inconveniently close together, with the idea that a substantial reduction of the resistance is thus secured. When there must be evolution of gas at an electrode, the majority of the resistance is at the electrodes, and it generally makes little difference how far the electrodes are apart within reason.

EMANCIPATION FROM SCIENTIFIC MATERIALISM.*

It has at all periods been a source of complaint that so little unanimity should prevail with regard to the most important and fundamental of human problems. In our own times, however, the grievance concerning one of the greatest of these questions has almost disappeared; for, although there still exists many and varied contradictions, nevertheless, it may be asserted that scarcely in any age has there been so comparatively close an agreement regarding our conception of the outer world of phenomena as exists in this present century. From mathematicians to practising doctor, every scientifically-thinking man, if called upon to express his opinion as to the "inner structure" of the universe, would sum up his ideas in the conception that things consisted of atoms in motion, and that these atoms and their mutual forces were the final realities underlying all phenomena. We read and hear, with countless repetition, the statement that the only intelligent explanation of the physical world is to be found in a "Mechanics of the Atoms;" matter and motion appear as the final principles to which natural phenomena in all their variety must be referred. This conception we may term scientific materialism.

At the third general sitting of the Assembly of the Society of German Scientists and Physicians at Lubeck, Prof. Wilhelm Ostwald (*vide* a translation in *Science Progress*) stated his conviction that this view is untenable; that this mechanical idea of the universe does not fulfil the purpose for which it was designed, and that it is inconsistent with undoubted and generally known and recognised truths. The conclusion to be drawn from this is obvious. The scientifically untenable view must be abandoned, and its place filled, if possible, by a new and better one. The natural question as to whether such another and better conception can be found, Prof. Ostwald thinks can be answered in the affirmative. His remarks consequently divide themselves naturally into two parts: a destructive part and a constructive part. As in all cases, so here, destruction is easier than construction; the inefficiency of the customary mechanical treatment is more easy to demonstrate than the efficiency of the new one, which he would characterise as the "energetical" view.

In order to find our way clearly through the infinite variety of the world of phenomena, we always make use of the same scientific method, namely, grouping together things that are similar, and in variety seeking the non-varying. In this way, our gradual mastery over the infinitely various phenomena of the outer world is acquired, and ever more effective means of co-ordination are continually developed. From the simple list we proceed to the system, from this again to the law of nature, and the most comprehensive form of the latter condenses into a general conception. We perceive that the phenomena of the actual world, limitless as is their variety, form nevertheless only certain perfectly definite and particular cases of the theoretically conceivable possibilities. The significance of a law of nature consists in the determination of the actual among the possible cases, and the form to which each can be referred is the finding of an invariant, that is to say, a quantity which remains unchanged even when all the other determining elements vary within possible limits imposed by law. Thus we perceive that the historical development of scientific conceptions is ever associated with the discovery and working out of such invariants; in them we behold the mile stones which mark the track traversed by human knowledge.

Such an invariant of universal significance was found in the idea of mass. This gives not only the constants of the laws of astronomy, but also appears no less invariable in the case of the most deep-going changes to which we can subject the objects of the outer world, namely, chemical changes. Accordingly this idea appeared to be excellently suited to form the central point of scientific law. Of course it was too poor in connotation to serve alone for the representation of the various phenomena, and had therefore to be correspondingly extended. This was effected by fusing with the simple mechanical idea the series of properties which are associated with the property of mass, and are proportional to it. In this manner arose the conception of matter, in which everything was summed up that was associated in our sense-impressions with mass, and which always accompanied it, as, for example, weight, extension in space, chemical properties, &c., and the physical law of the conservation of mass passed into metaphysical axiom of the conservation of matter.

But even the extended idea of matter, together with the necessary attendant suppositions, is not sufficient to embrace all phenomena, not even, indeed, in the inorganic world.

We think of matter as something in itself intrinsically motionless and unvarying; hence, in order to make the representation of an ever-changing world possible, we must supplement this conception with another independent one which gives expression to this changeableness. A conception of this sort was, in the most successful manner, developed by Galileo, the founder of scientific physics, in the idea of force as the constant cause of motion. Though Newton and the early French astronomers arose the mechanical conception of nature according to which all phenomena (at first of inorganic nature) were to be finally referred simply to the motions of atoms according to the same laws which had been recognised to hold for heavenly bodies. That this conception should be immediately carried over from the region of inorganic to that of animated nature, was a necessary consequence when it was once perceived that the same laws which hold in the former, claim here, also, their inviolable rights. This conception of the universe found its classical expression in Laplace's idea of the "Universe Formula," by means of which every past and future event was to be capable of deduction by rigid analysis applied to mechanical laws.

We do not generally notice in what an extraordinary degree this widespread view is hypothetical, nay, metaphysical; on the contrary, we usually regard it as the most exact expression for the actual relations. Nevertheless, it must be remarked that a confirmation of the natural deduction from this theory, namely, that all non-mechanical phenomena such as heat, radiation, electricity, magnetism and chemical action are actually mechanical, has in no single case been obtained. In no single case has the attempt to represent the actual relations by means of a mechanical system so far succeeded that nothing remained over to explain. For many individual phenomena, the mechanical analogues have been given with more or less success. But all attempts to completely represent the whole of the known facts in any department by means of some such mechanical analogue have resulted, without exception, in some unexplainable contradiction between what really happens, and what we should expect from our mechanical model. This contradiction may long remain hidden; but the history of science teaches us that it sooner or later makes its inevitable appearance, and that all we can say with complete certainty regarding such mechanical similes or analogues—usually termed mechanical theories of the phenomena in question—is that they will doubtless on some occasion fail.

The history of optical theories offers a striking example of these facts. The life of the vibration theory, as a mechanical theory, has had its bounds, for in our own time it, too, has been carried to its grave without drum or fife, and its place taken by the electro-magnetic theory of light. A postmortem examination reveals clearly the cause of death; it has resulted from the failure of the mechanical parts. The hypothetical ether, whose task it was to "beat," had to fulfil its duty under particularly difficult conditions. For the phenomena of polarisation demanded unconditionally that the vibrations should be transversal. Now this presupposes a solid body, and the calculations of Lord Kelvin have finally shown that a medium, with such properties as were thus required of the ether, could not possibly be stable, and, as a necessary consequence, can have no physical existence. Doubtless the idea of sparing the now generally received electro-magnetic theory of light a similar fate prompted the immortal Hertz, to whom this theory owes so much, when he expressly declined to see in it anything beyond a system of six differential equations.

The net result of the foregoing remarks is in the first place purely negative. We have learned how not to proceed, and it may appear of little use to bring forward such negative results. However, in this way we discover the possibility of critically correcting views, which, in their own time, created no small sensation, and caused many of those interested great trouble, namely, the widely known views first expounded twenty-three years ago by the celebrated Berlin Professor of physiology, Emil du Bois-Reymond, at the Leipzig meeting of the German Association of Natural Philosophers, and later in some other much-read papers, views dealing with the prospects of our future

* Condensed from a paper in *Science Progress*, Vol. iv., No. 24, p. 419—436.

knowledge of nature and culminating in the much-discussed *ignorabimus*. In the long controversy which this speech gave rise to, du Bois-Reymond has victoriously withstood all attacks, and naturally so, since all his opponents have proceeded from the same premises which led him to his *ignorabimus*, and his conclusions stand as firm as the basis upon which he built them. The basis, which meanwhile had been called in question by no one, is the mechanical conception of the universe, namely, the assumption that the resolving of phenomena into a system of moving particles is the goal to be aimed at in our explanation of nature. Should, however, this foundation fall—and we have seen that it must—then with it goes the *ignorabimus*, and science is once more free to move onward.

What has been set forth, however, has a far wider significance. The doing away with the mechanical construction of the universe goes down to the very foundations of the whole materialistic conception of things, taking the word materialistic in its scientific sense. If it appears a vain undertaking, ending with every serious attempt in final failure, to give a mechanical representation of the known phenomena of physics, we are driven to the conclusion that similar attempts in the incomparably more complicated phenomena of organic life will be still less likely to succeed. The same fundamental contradictions occur here also, and the assertion that all the phenomena of nature can be primarily referred to mechanical ones cannot even be designated here as a practical working hypothesis; it is simply incorrect.

We must accordingly give up all hope of getting a clear idea of the physical world by referring phenomena to an atomistic mechanics. Instead, we must try to co-ordinate realities, *i.e.*, definite and measurable quantities, so that when certain of them are given, the others can be deduced. This is the problem set before science, and this problem cannot be solved by assuming as substratum any hypothetical analogue, but only by the determination of the mutual relations existing between measurable magnitudes.

Undoubtedly this way is long and tiring, yet it is the only permissible one. But we need not tread this path with bitter self-renunciation, hoping that it will finally lead our grandchildren to the longed-for summit. No, it is we who are the fortunate ones, and the most hopeful bequest which the departing century can bestow on the one that is just dawning, is the replacement of the mechanical by the "energetical" conception of the universe. The energetical conception of the universe is by no means a novelty. When Julius Robert Mayer, 53 years ago, first discovered the equivalency of the various natural forces, or as we now say, the various forms of energy, he had already taken an important step in the critical direction. But, according to an ever recurring law in collective thinking, a new idea is never accepted in the pure and unsullied form in which it is offered.

When Mayer had set forth the law of equivalency, his idea of equivalent transmutability of the different forms of energy was, in its simplicity, too strange to be directly accepted. Indeed, the three scientists, to whom we are mostly indebted for the working out of this law—Helmholtz, William Thomson, and Clausius—all three believed that the law could be "explained" by assuming that the different forms of energy were fundamentally the same, namely, mechanical in nature. In this way, what appeared to be the most urgent need was satisfied, namely, a direct connection with the dominating mechanical conception of nature. But a fundamental part of the new thought was thereby lost.

Half a century has been necessary to mature the conviction that this hypothetical addition to the law of energy is in reality no deepening of insight, but a renunciation of its most important aspect—its freedom from every arbitrary hypothesis. It is not, however, the recognition of this general fact which actually brought about this advance, namely, the rejection (as far as it has gone) of the mechanical explanation, but rather the final failure of all attempts to interpret satisfactorily by the mechanical treatment the phenomena connected with the remaining forms of energy.

But how is it possible, by such an abstract idea as energy, to form a conception of the universe which shall be comparable, in clearness and intuitiveness, with the mechanical one. The answer ought not to be difficult. What do we know of the physical world? Obviously only what is vouchsafed us through our organs of sense. But under what conditions are these organs set in action? Turn the matter as we may, the only principle we find common to all is this: The organs of perception react in response to differences of energy between them and the surroundings. In a world in which the temperature was everywhere that of our bodies, we should have no experience of heat, just as we have no perception of the constant atmospherical pressure under which we live. Not till we have produced a space of different pressure, do we become aware of its existence.

This will be readily admitted. But scientists will not be so ready to abandon the matter, for energy must, of course, have a carrier. Ostwald, therefore, asks in return: Why? Since our total knowledge of the outer world consists in its energy relations, what right have we to assume in this very outer world the existence of something of which we have had no experience? But energy, it has been urged, is only something thought of, an abstraction, while matter is a reality; exactly the reverse, says Ostwald. Matter is a thing of thought which we have constructed for ourselves (rather imperfectly) in order to express that which is lasting in the changeableness of phenomena. Now that we begin to grasp that the actual, *i.e.*, that which acts upon us, is energy alone, we must inquire in what relation the two conceptions stand to one another, and the result is undoubtedly that the predicate of reality can be affirmed by energy only.

This decisive aspect of the new conception will, perhaps, stand out more clearly if the development of the idea in question is sketched in a short historical *resumé*. Progress in science is characterised by the discovery of ever more general invariants. Mass was extended to matter, *i.e.*, mass accompanied by volume, weight, and chemical properties. This conception was, however, obviously insufficient to embrace phenomena in their continual changeableness, and from Galileo's time onwards, the idea of force has been added in order to suit this phase of nature. But force lacked the property of constancy, and after *vis viva* and work had been found to be mechanical functions exhibiting the properties of partial invariants, Mayer discovered in energy the most general invariant which rules the whole dominion of physical forces.

In accordance with this historical development, matter and energy continued to exist side by side, and all that could be said about their mutual relation was that they occurred for the most part together, or that matter was the carrier or holder of energy.

But are matter and energy things essentially different from one another, as perhaps body and soul? Or is not rather all that we know and say of matter already contained in the idea of energy, so that we can represent with this latter quantity the totality of phenomena? There can be no doubt as to the answer. Hidden in the conception of matter are the following ideas: First of all mass, that is, the capacity factor of kinetic energy; further, the occupation of space or volume energy; again, weight or that particular kind of distance energy which appears as gravitation; and finally, chemical properties, *i.e.*, chemical energy. It is always a question of energy alone, and if we imagine the various kinds of energy removed from matter there remains nothing, not even the space it occupied; for space makes itself known only through the expenditure of energy which the penetration into it requires. Matter is, therefore, nothing but a group of various forms of energy co-ordinated in space, and all that we try to say of matter is really said of these energies.

These considerations show that all that we have until now been able to express by the ideas of matter and force—and, indeed, much more besides—may actually be expressed by the idea of energy. It is a question simply of transferring to this conception those properties and laws which were formerly ascribed to matter and force. By making no assumption as to the relation between the different forms of energy, except that given by the law of conservation, we leave ourselves free to study objectively the various properties of these forms of energy.

The mechanical method signally breaks down in chemical problems. The factors of electrical energy, potential and electrical quantity, form a case in point—quantities which may be called polar, *i.e.*, they are characterised not only by a numerical value, but also by a sign in such a way that the sum of two equal values, with opposite signs, is equal to zero, and not to their double value. In mechanics, the purely polar quantities are unknown, and this is why all attempts to set up even a partially workable mechanical hypothesis for electrical phenomena must essentially fail. Should we succeed in contriving a mechanical magnitude with polar properties (as is, perhaps, not impossible, and certainly worthy of careful consideration), we should have the means wherewith to picture to ourselves mechanically, at least, a few phases of electrical phenomena. We may say with certainty that it will be a question of a few only, and that the imperfection of all mechanical hypotheses will show itself here again, and will prevent the complete carrying out of the idea.

But even if the laws of natural phenomena may really be reduced to the laws of the corresponding forms of energy, what advantage do we gain therefrom? First, the very considerable one, that a science free from hypothesis becomes possible. We seek no longer forces whose existence we cannot prove between atoms which we cannot observe, but we judge a process by the kind and quantity of the vanishing and appearing energies. These we are able to measure, and all that it is necessary to know may be expressed in this manner. What an enormous general advantage this is will be clear to every one whose scientific conscience has suffered under the continual amalgamation of facts and hypothesis which the physics and chemistry of to-day offer us as rational science. Energetics offers us a means of fulfilling in its true sense the demand of Kirchhoff so oft misunderstood, namely, the substitution of the description of phenomena for the so-called explanation of nature. With this freedom from hypothesis appears a methodical unity which, it may be unhesitatingly affirmed, has up till now never been attained.

There is a final question, which must not pass untouched. When we once succeed in grasping in its pure entirety a fruitful and important truth, we are only too apt to look upon it as all-comprehensive. This mistake we see daily committed in science, and the mechanical conception of phenomena has arisen from exactly such a cause. We shall forthwith have to ask ourselves the question: Is energy necessary and useful as it is for the understanding of nature, also sufficient for this purpose? Or are there phenomena which cannot be completely represented by the known laws of energy?

This question Ostwald answers with an emphatic negative. Immense as are the advantages possessed by the energetical conception of the universe over the mechanical or materialistic, it seems, nevertheless, that already certain points may be noted which are not covered by the known laws of energy, and which, therefore, point to the existence of principles which extend beyond these. Energetics will remain beside these new laws; but it will not be in the future, as we must to-day consider it; it will perhaps appear as a special case of a still more general relation, of the nature of which we can at present have scarcely an inkling.

We are thus again met by the facts that science may never recognise bounds to her progress, and that amidst the struggles for some new possession, her eyes must not become blinded to the fact that, beyond the territory she is striving to conquer, still wider plains extend, which later must also be subdued. Let us have done with the time when the smoke and the dust of battle confined our vision to the narrow limits of the combat. To-day that is no longer allowed; to-day we fire with smokeless powder—or, rather, ought to do so—and have, therefore, with the possibility, also the duty not to fall into the errors of past periods.

NEW PATENTS AND ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Compiled expressly for this journal by* W. P. Thompson & Co., *Electrical Patent Agents, 322, High Holborn, London, W.C., to whom all inquiries should be addressed.*]

NEW PATENTS.—1896.

19,290. "Improvements in or relating to electrical furnaces." A. J. Boult. (O. Patin, France.) Dated September 1st.

19,301. "Improvements in storage batteries." A. Preiss. Dated September 1st.

19,303. "Improvements in electro-magnets." T. McKenna. (Electric Selector and Signal Company, United States.) Dated September 1st. (*Complete.*)

19,304. "Improvements in electric selectors and adaptations thereof, and in transmitters therefor." T. McKenna. (Electric Selector and Signal Company, United States.) Dated September 1st. (*Complete.*)

19,305. "Improvements in electrical selecting instruments." T. McKenna. Dated September 1st. (*Complete.*)

19,308. "Improvements in utilising the residual products obtained in the working of certain kinds of voltaic batteries." W. Walker, jun., F. R. Wilkins, J. Lones, and Joseph Lones. Dated September 1st.

19,316. "Improvements in electric lamps." L. A. Jackson and Acme Electric Lamp Company. Dated September 1st.

19,396. "A new or improved combined electric lamp and walking stick." J. D. Lawrence. Dated September 2nd.

19,399. "Improvements connected with the electrical coating of tubes, rods, and the like, and apparatus therefor." W. S. Rawson. Dated September 2nd.

19,455. "Improvements in automatic switches and safe-guards for electric traction systems." S. P. Thompson and M. W. Morland. Dated September 3rd.

19,456. "An electric traction system." S. P. Thompson and M. W. Morland. Dated September 3rd. (*Complete.*)

19,469. "A means of surrounding electric or other lights with a vessel or lining of glass or other material containing liquids." E. J. Macready. Dated September 3rd.

19,501. "Improvements in electric light conduits." B. M. Drake and J. M. Gorham. Dated September 3rd.

19,505. "Improved methods and apparatus for electro-thermally treating materials." H. Maxim. Dated September 3rd.

19,507. "Improvements in electrical arc lamps." H. C. Madsen. Dated September 3rd. (*Complete.*)

19,528. "Improvements in dynamo-electric machines and electric motors." S. A. Nash. Dated September 3rd.

19,558. "Improvements in printing telegraph instruments." E. M. D. Andre. Dated September 4th.

19,583. "Automatic closing telegraphic key." J. A. Coleman. Dated September 4th.

19,638. "Improvements in electrical indicators." I. H. Parsons. Dated September 5th.

19,639. "An improved mode of electrical gas lighting." A. Lege. Dated September 5th.

19,650. "Improvements in insulators." T. Blankinsop and J. W. Brown. Dated September 5th.

19,660. "Improvements in or relating to apparatus for supplying a certain definite amount of electric current (for lighting or other purposes) on prepayment." W. D. Watson. Dated September 5th.

19,664. "Improvements in glass globes or shades for electric, gas or other lights." Sowerby's Ellison Glass Works, Limited. Dated September 5th.

19,693. "An improved electric switch for certain useful purposes." W. C. Bersey, E. F. Moy, and E. F. Moy, Ltd. Dated September 5th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Copies of any of these Specifications may be obtained of* Messrs. W. P. Thompson & Co., 322, High Holborn, W.C., *price, post free,* 8½*d.* (*in stamps*).]

1895.

16,521. "Improvements in and connected with the overhead system of electric traction." W. C. Bersey. Dated September 3rd, 1895. Relates to electric tractions by overhead lines and trolley collectors, constructed of a jointed toggle, or diamond shaped frame, in which are mounted three grooved travelling wheels, one at each end bearing upwards against the wire, and an intermediate one at upper middle joint bearing downwards upon the wire. A constant pressure upon the wire is maintained by a spring, which ensures continuous contact and avoids jumping and sparking, and adapts the trolley to pass the points of support of the wires. 3 claims.

17,365. "Improvements in motor vehicles for electric railways." R. Belfield. Dated September 17th, 1895. Relates to arrangements for coupling electric motor vehicles in a train in such a manner that all the motors of the vehicles can be controlled by one of the switches in any of the vehicles; at the same time when the train is broken up each vehicle forms an independent unit capable of being operated by itself. 5 claims.

17,430. "Improved method of and means for making and breaking electric circuits." R. Belfield. Dated September 18th, 1895. The objects of the invention are to provide for making and breaking an electric circuit automatically when the current in another circuit becomes greater or less than a certain predetermined value, and also to provide means for making and breaking a circuit at a distance. The apparatus comprises a switch which is operated by an electric motor, the supply of current to the motor and the direction of rotation of the same being determined by the current flowing in an adjacent circuit through the agency of an electro-magnet. 7 claims.

17,481. "Improvements in electroliers." R. H. Best. Dated September 19th, 1895. Relates to electroliers to permit the ready adjustment of the lamp to the required height without obstruction to the conductor fitted within the pendant. A metal socket tube is employed, having a bracket for carrying the chain pulleys of the counter-balancing appliances. This tube has a screw cup for its lower end, with an angularly shaped aperture to admit a similarly shaped sliding tube, to the lower extremity of which the lamp is attached. An internal coiled conductor is placed within the socket tube and secured to the sliding tube and the upper part of the socket tube by means of a grip to prevent twisting and turning. Thus a free vertical movement of the conductor by the opening and closing of the coil with the downward and upward movement of the lamp is provided. 3 claims.

19,353. "Improvements in electric gas-lighting apparatus." J. Johnson. Dated October 15th, 1895. Refers to specification No. 3,085 of 1895. Relates to modifications made in the construction of the lower guide of the lighter. These consist in causing the alternation of deep with shallow notches, in any pre-determined number and sequence, suitable to the requirements of the service in each particular case, for the purpose of enabling only a certain number of lamps belonging to the same district area or pipe system to be lit or extinguished. 1 claim.

1896.

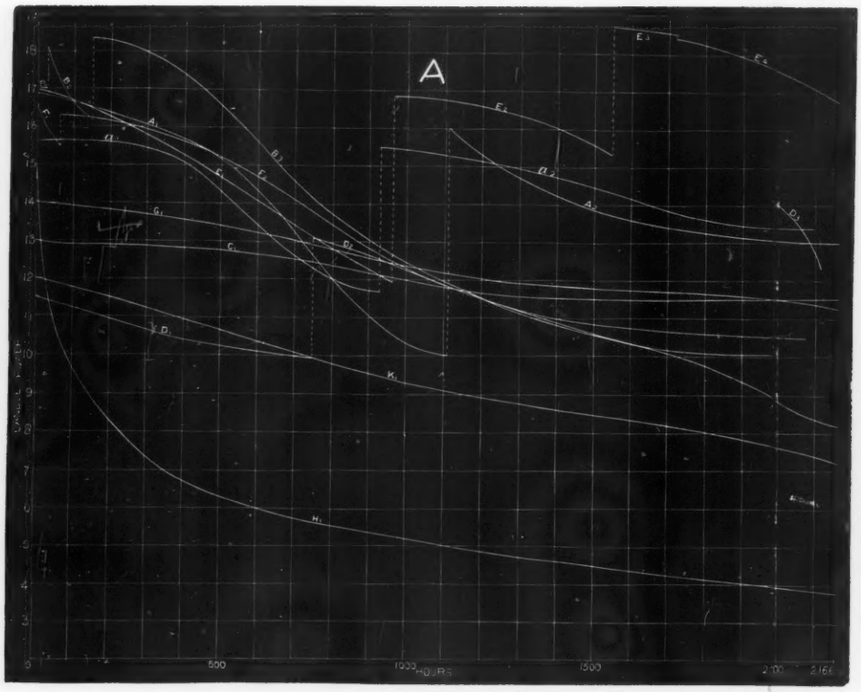
13,046. "Improvements in and connected with cleats for electric and other wires and the like." F. B. Evans. Dated June 13th, 1896. Relates to improvements in porcelain cleats supported by screws which consists in facilitating the putting up of electric wires by having the two parts of the cleat of exactly the same form and size, thus requiring no trouble in "mating" the two parts. Strength in gripping the wire is afforded by providing small offsets on each part, which, when placed together, form angular holes for the wires so as to take wires of different sizes; this also prevents twisting tendency from unequal strain when two wires are used. 3 claims.

14,499. "Improvements in microphones." F. Stock. Dated June 30th, 1896. Relates to a new construction of microphone as follows:—Circular carbon discs are provided with bores and a round carbon stick is put through the latter to carry the discs, thus a series of contacts are obtained by placing a vertical carbon vibrating membrane against the periphery of the discs. The density of these contacts depends upon the manner in which the discs are pressed downwards. On speaking against the membrane the discs begin to vibrate and simultaneously begin a slow but regular rotation round their suspension point. With this rotation is connected the essential advantage that the touching places remain free from dust, which also effects favourably the clearness of speech. 2 claims.

ELECTRICAL REVIEW
SPECIAL SUPPLEMENT.

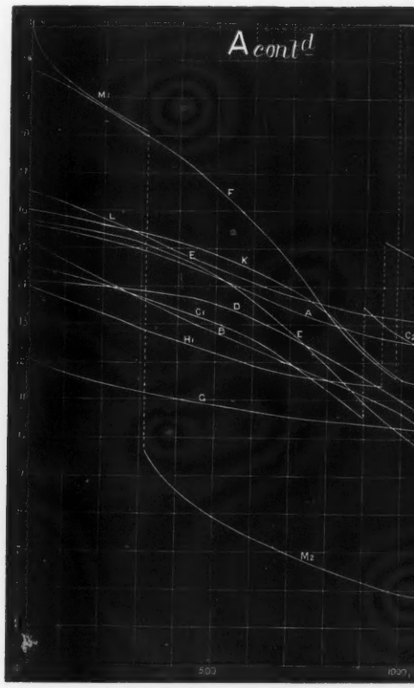
ELECTRIC GL

BY WILLIAM HENRY PRE



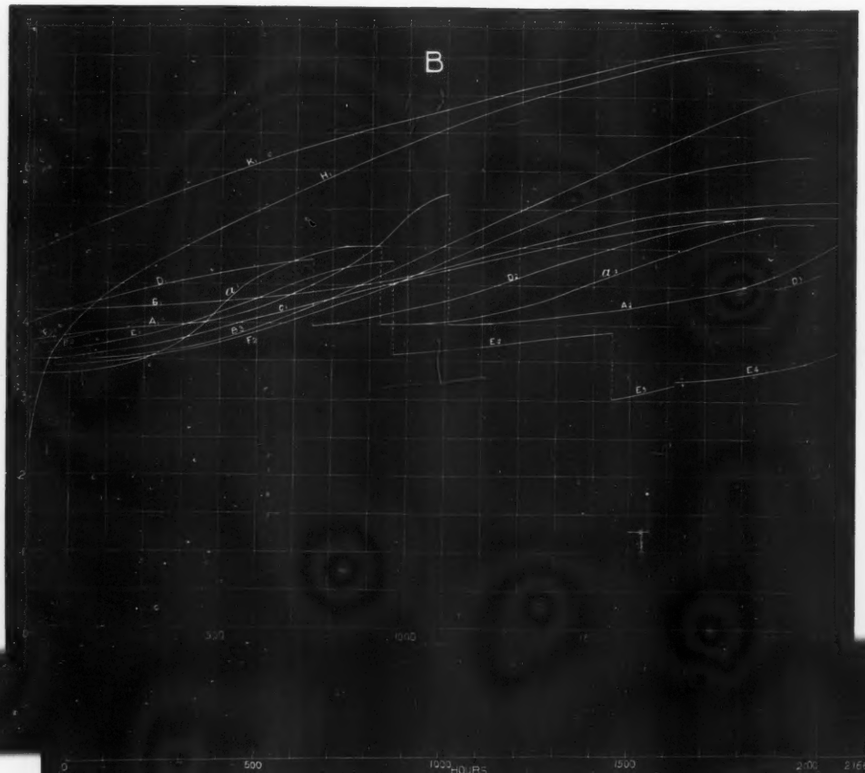
A, Edison-Swan .. .. .. 105 volts, 16 C.P.
a „ .. .. .. 100 „ 16 „
B, Siemens Bros. .. .. .. 105 „ 16 „
C, Brush Company .. .. 100 „ 16 „
D, Laing, Wharton & Down .. 105 „ 16 „
E, Stearn .. .. .. 105 volts, 16 C.P.
F, International Electric Co. 105 „ 16 „
G, Bishop's Cluster Co. .. 105 „ 16 „
H, Electrical Co., Limited .. 105 „ 16 „
K, Sunbeam Lamp Co. .. 105 „ 16 „

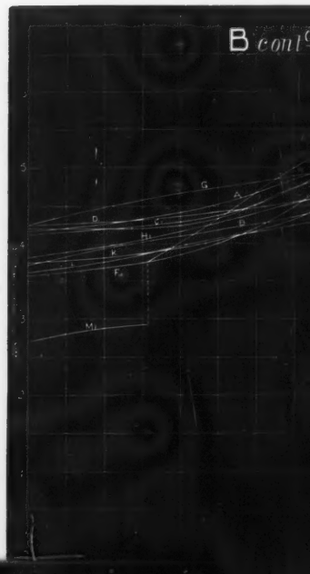
CURVES OF CANDLE-POWER AND LIFE.



A, Electrical Company .. 105 volts, 16 C.P.
B, Barclay & Son .. .. 105 „ 16 „
C, Sturm & Co. .. .. 105 „ 16 „
D, F. Walters & Co. .. .. 105 „ 16 „
E, Conze & Simon .. .. 105 „ 16 „
F, General Electric Co. .. 105 „ 16 „
G, G. Straus .. .. .. 105 „ 16 „
H, Lowcock, Hill & Co. .. 105 „ 16 „
K, James Shaw .. .. 105 „ 16 „
L, Rose & Bird .. .. 105 „ 16 „
M, Mackey, Mackey & Co. .. 105 „ 16 „

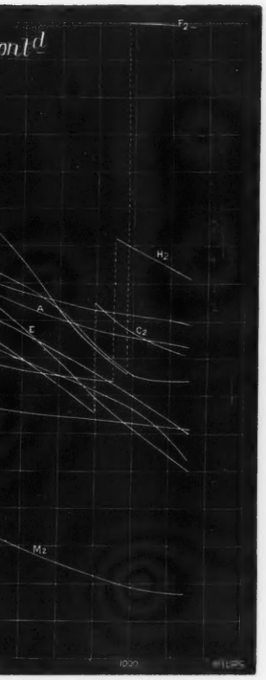
CURVES OF CANDLE-POWER AND LIFE.





GLOW LAMPS.

Y PREECE, C.B., F.R.S., &c.



.. 135 volts, 16 C.P.
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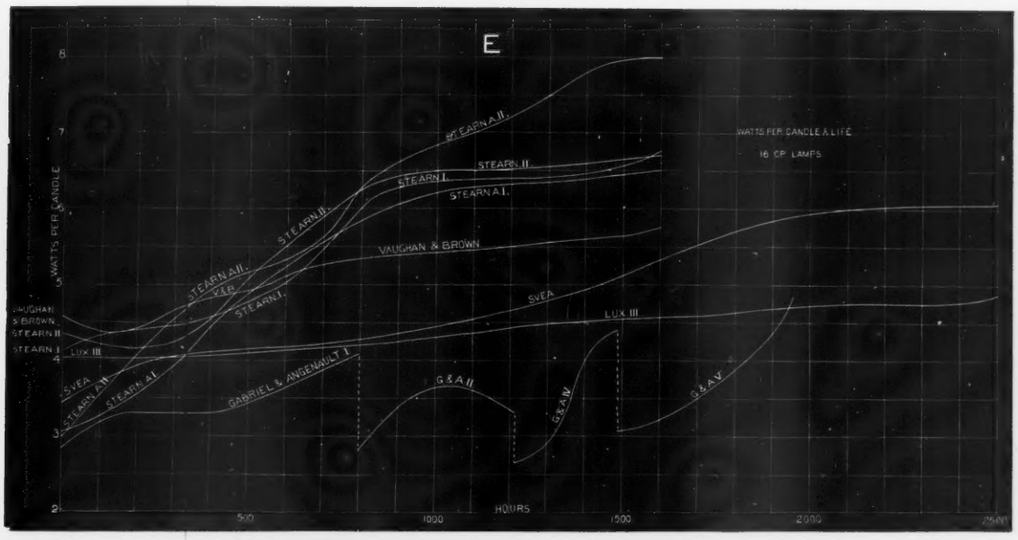
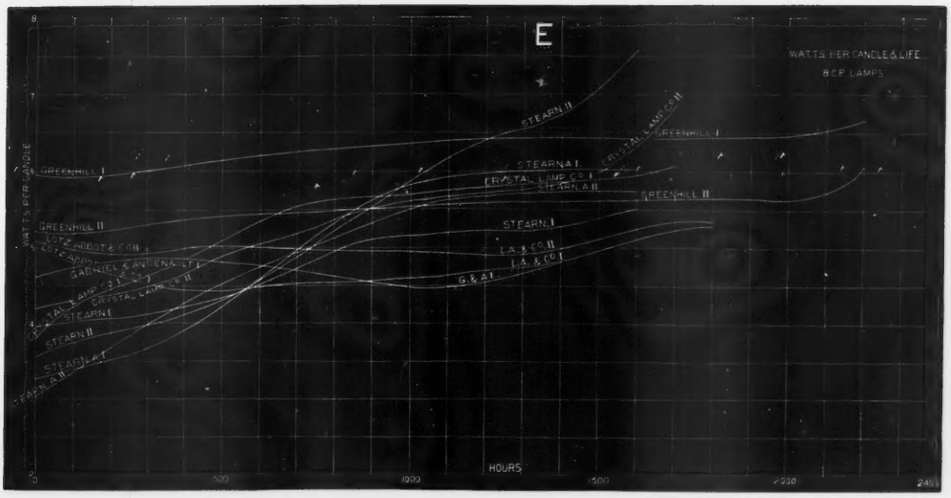
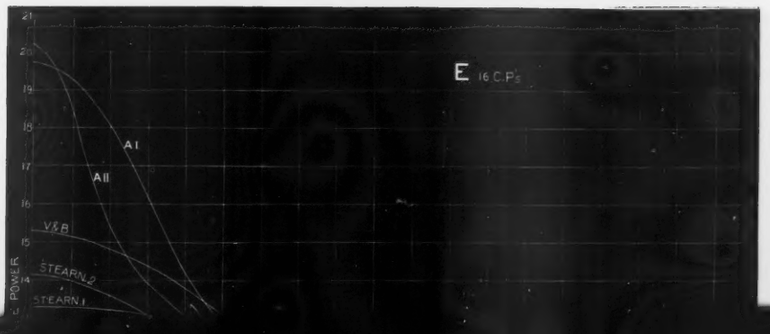
-POWER AND LIFE.







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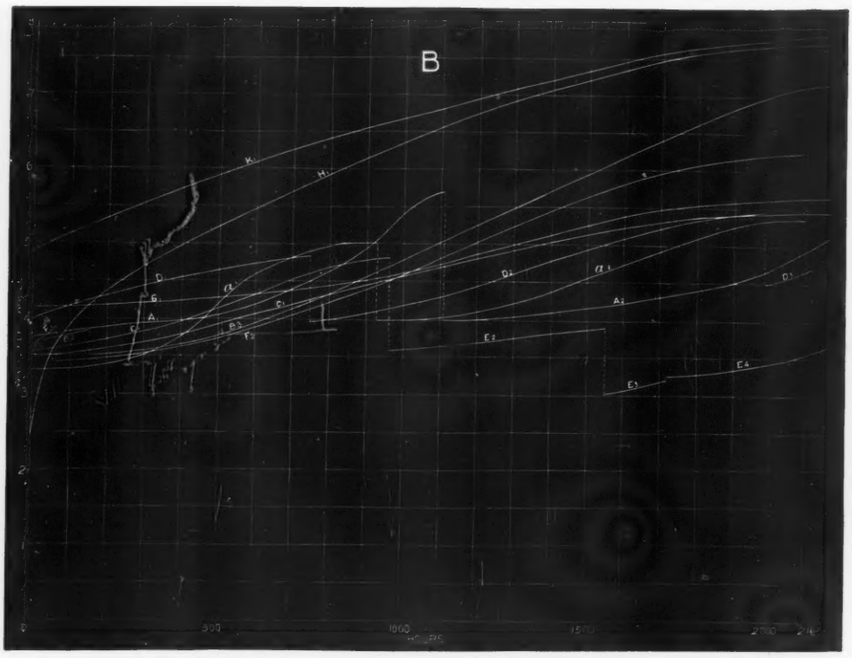
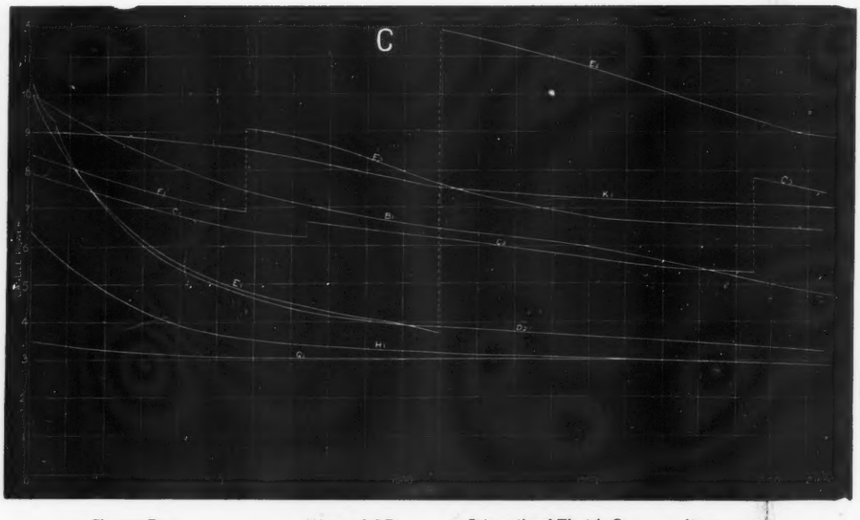
C, Brush Company .. .. 100 „ 16 „
D, Laing, Wharton & Down .. 105 „ 16 „
E, Stearn .. .. .. 105 volts, 16 C.P.
F, International Electric Co. 105 „ 16 „
G, Bishop's Cluster Co. .. 105 „ 16 „
H, Electrical Co., Limited .. 105 „ 16 „
K, Sunbeam Lamp Co. .. 105 „ 16 „

CURVES OF CANDLE-POWER AND LIFE.

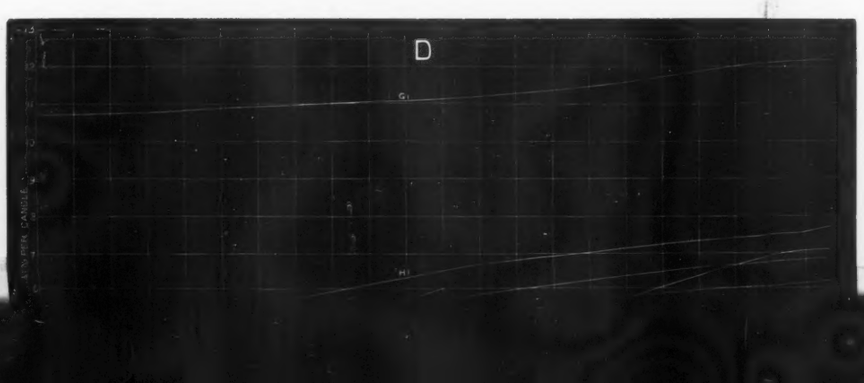


EFFICIENCY CURVES, CORRESPONDING TO CURVES A.



B, Siemens Bros. .. .. .. 100 volts 8 C.P.
C, Brush Co. .. .. .. 100 „ 8 „
D, Laing, Wharton & Down .. 100 „ 8 „
E, Stearn .. .. .. 100 „ 10 „
F, International Electric Co. .. 100 volts 8 C.P.
G, Bishop's Cluster .. .. 100 „ 8 „
H, Electrical Co., Limited .. 105 „ 8 „
K, Sunbeam Lamp Co. .. 100 „ 8 „

CURVES OF CANDLE-POWER.



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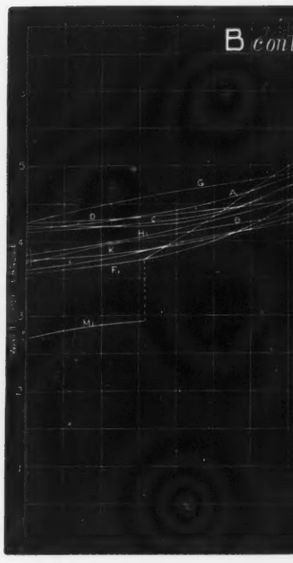
M, Mackey, Mackey & Co. .. 105 „ 16 „

CURVES OF CANDLE-POWER AND LIFE



EFFICIENCY CURVES, CORRESPO

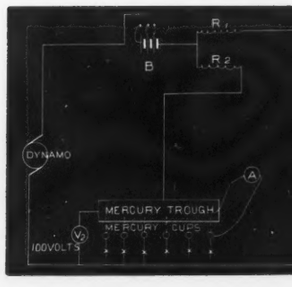


FIG. 1.

FIG. 2.

.. 135 volts, 16 C.P.,
.. 105 „ 16 „
.. 105 „ 16 „
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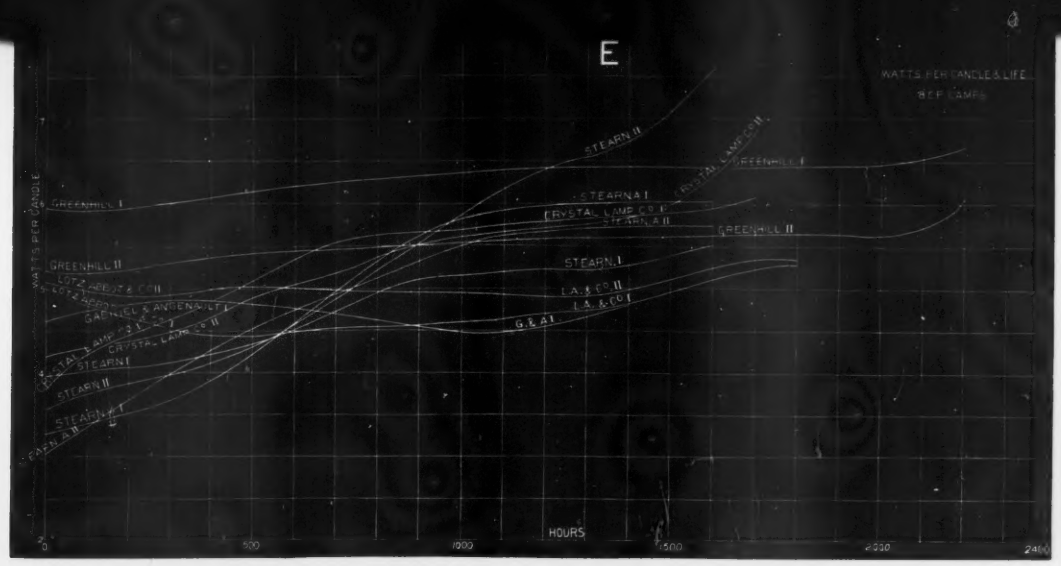
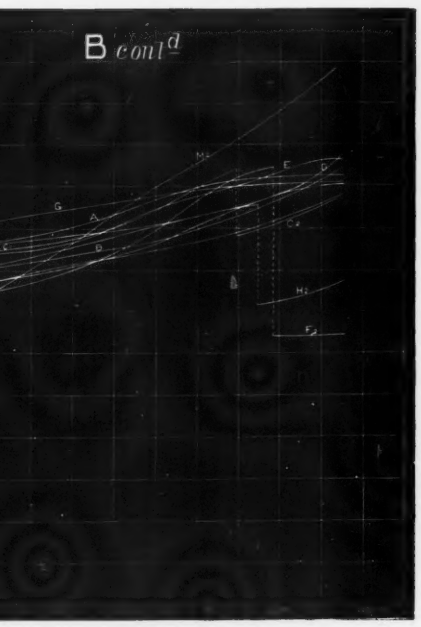
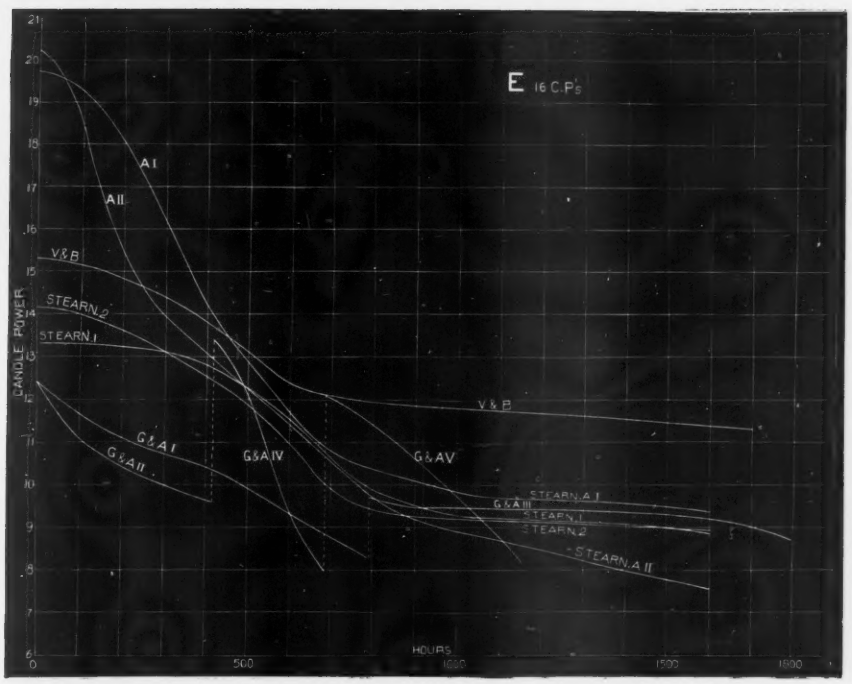
Co.. 105 „ 16 „

E-Power and Life.





Curves, Corresponding to Curves A.



Vaughan & Brown, 105 volts, 16 C.P. Stearn A I., 105 volts, 16 C.P. Stearn A II., 105 volts, 16 C.P.
Stearn 1., 105 volts, 16 C.P. Stearn 2, 105 volts, 16 C.P. Gabriel & Angenault, I., II., III., IV. and V., 105 volts, 16 C.P.

Curves of Candle-Power and Life.

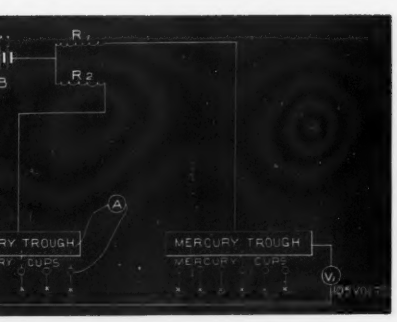
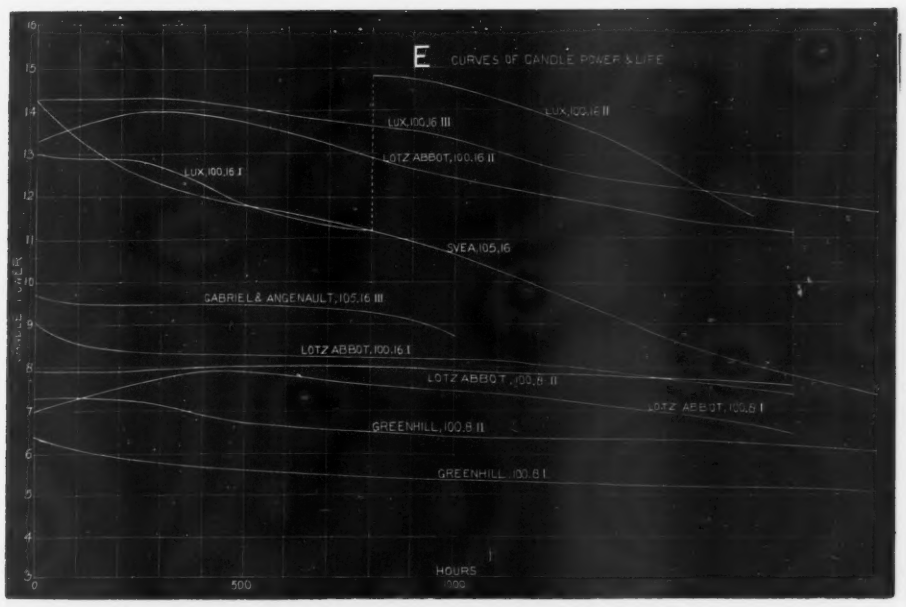


Fig. 1.



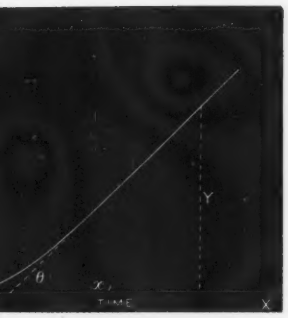
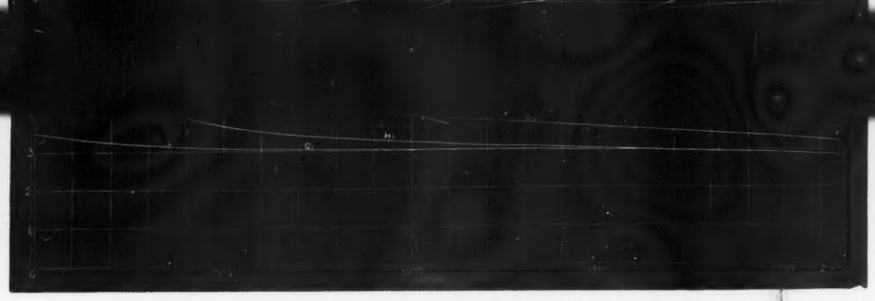


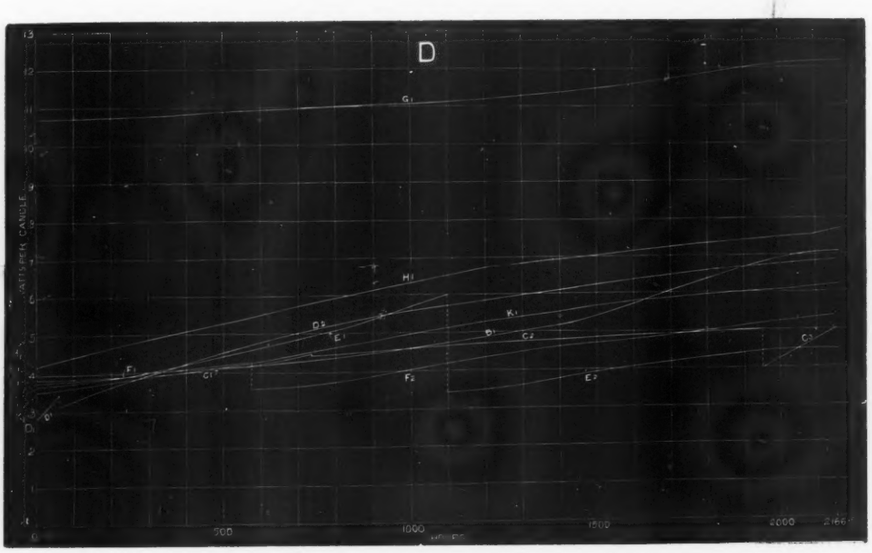
Fig. 2.



B, Siemens Bros. .. .. .. 100 volts 8 C.P.
C, Brush Co. .. .. 100 „ 8 „
D, Laing, Wharton & Down .. 100 „ 8 „
E, Stearn .. .. .. 100 „ 10 „
F, International Electric Co. .. 100 volts 8 C.P.
G, Bishop's Cluster .. .. 100 „ 8 „
H, Electrical Co., Limited .. .. 105 „ 8 „
K, Sunbeam Lamp Co. .. .. 100 „ 8 „

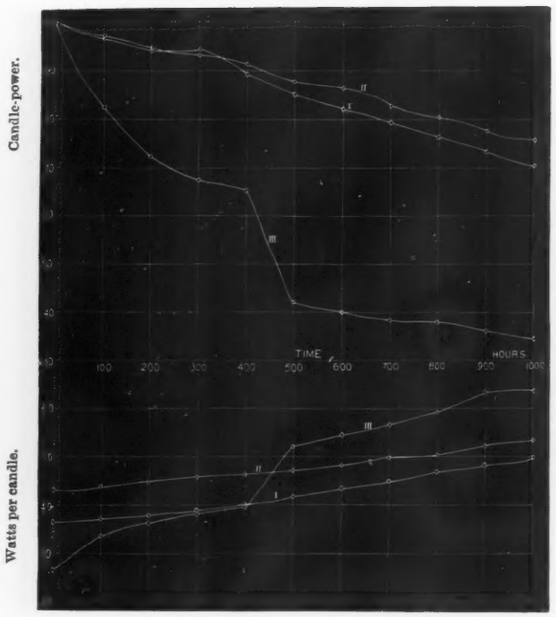
CURVES OF CANDLE-POWER.

FIG. 2.



EFFICIENCY CURVES CORRESPONDING TO CURVES C.

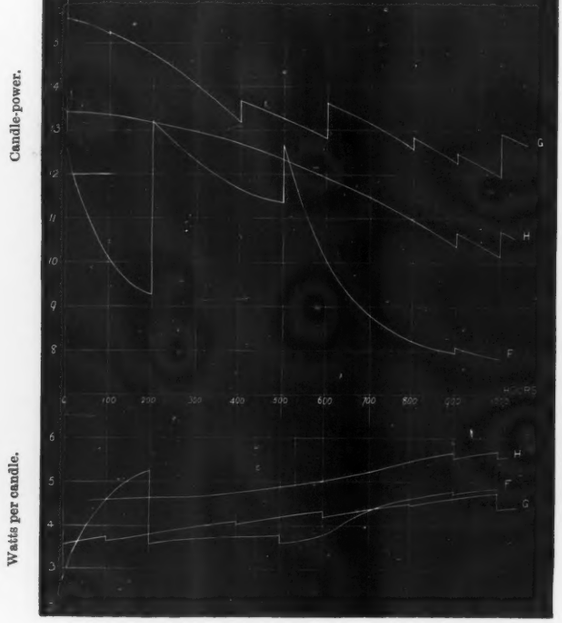
DIAGRAM TO TA



I., for lamps of initial watts per C.P. of 3 to 4.
II. „ „ „ of over 4.
III. „ „ „ of 2 to 3.

CURVES CONNECTING TIME WITH C.P. (PERCENTAGE) AND WATTS PER CANDLE RESPECTIVELY.

Sheet 1.



H, 14 lamps of over 4 watts per candle.
G, 19 „ „ 3 to 4 „ „
F, 3 „ „ 2 to 3 „ „

CURVES CONNECTING TIME WITH C.P. PER LAMP AND WATTS PER CANDLE.

Sheet 2.

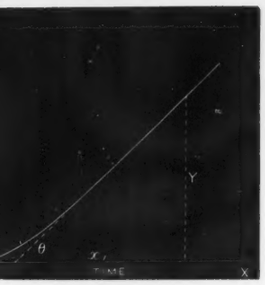
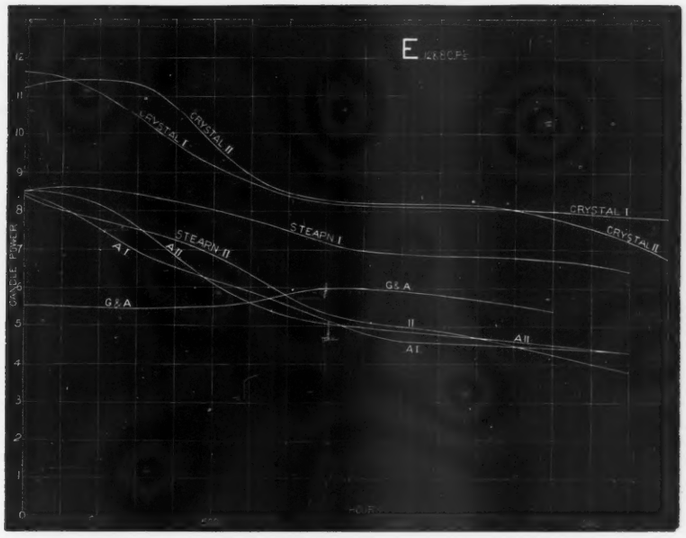


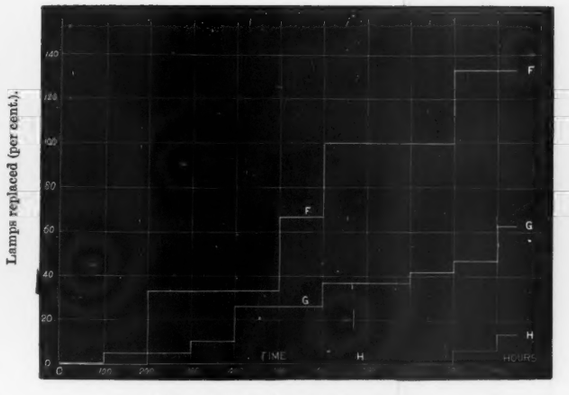
FIG. 2.

DIAGRAM TO TABLE I.



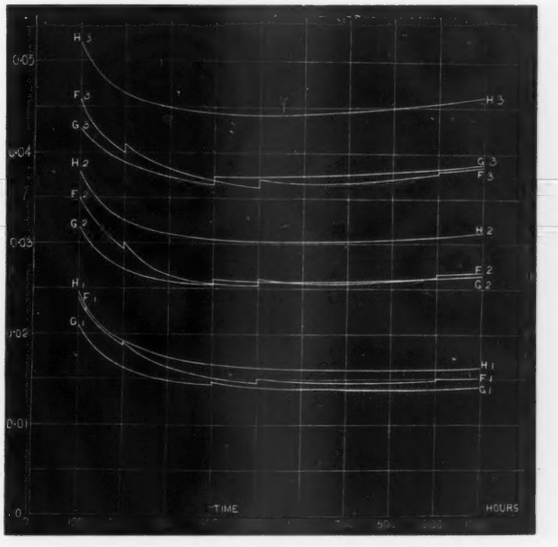
Crystal Company, 57 volts, 12 C.P., No. I. Stearn 105 volts, 8 C.P., A I. Stearn, 105 volts, 8 C.P., I.
" 57 " 12 " No. II. " 105 " 8 " A II. " 105 " 8 " II.
Gabriel & Angenault, 100 volts, 8 C.P

CURVES OF CANDLE-POWER AND LIFE.



H, 14 lamps, initial watts per candle over 4.
G, 19 " " " between 3 and 4.
F, 3 " " " " 2 " 3.

CURVES SHOWING PERCENTAGE OF LAMPS REPLACED.
Sheet 3.



H, lamps of initial watts per candle over 4. 1. B.T.U., at 3d.
G " " " from 3 to 4. 2. " " 6d.
F " " " " 2 " 3. 3. " " 9d.

CURVES CONNECTING COST PER CANDLE-HOUR AND TIME.
Sheet 4.